SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1915.

CONTENTS.

GENERAL PHYSICS.

PAGE
1595. Apparatus for Determination of Acceleration. *B. Galitzine* 625
1596. Strength of Cylinders closed by Plugs. *A. G. Hadcock* 625
1597. Best Form for Balance Beams. *R. Strömberg* 625
1598. Effect of Heating on Elasticity of Aluminium. *H. L. Dodge* 626
1599. Stress Distribution in Engineering Materials 626
1600. Amount of Fluid delivered by Constricted Pipe. *J. Boussinesq* 627
1601. Water-hammer in Pipes. *C. Camichel* 627
1602. Water-hammer in Air-free Pipes. *C. Camichel* 628
1603. Method of Small Oscillations in Atomic Dynamics. *R. Seeliger* 628
1604–1610. 629
1611. Drop-weight Method for Surface-tensions. *A. Ferguson* 630
1612. Flow of Liquids in Drops. *P. Vaillant* 630
1613. Photography of Currents in Liquids. *J. Zenneck* 630
1614. Quantum Theory and Molecular Structure. *D. A. Goldhammer* 631
1615. Atmospheric Pressure in Equatorial Africa. *R. Chudeau* 631
1616. Air Calculation of the Globe. *W. H. Hobbs* 631
1617. Region of Greatest Snowfall in the United States. *A. H. Palmer* 632
1618. The Measurement of Evaporation. *B. E. Livingston* 632
1619. Solar Halo of May 11, 1915. *C. G. Andrus, C. S. Hastings* 633
1620. Total Radiation from Sky at Washington. *H. H. Kimball* 633
1621. Solar Constant of Radiation. *C. G. Abbot, F. E. Fowle, & L. B. Aldrich* 633
1622. Wave produced by Depression of Sea Bottom. *K. Sano & K. Hasegawa* 634
1623. Geological Theory of Earth's Interior. *T. C. Chamberlin* 634
1624. Structure of Earth's Interior. *H. F. Reid* 635
1625. Study of Earth's Structure. *J. F. Hayford* 635
1626. Solar Radiation outside the Atmosphere. *C. G. Abbot, F. E. Fowle, & L. B. Aldrich* 635

PAGE
1627. Plane of the Solar Motion. *S. Oppenheim* 635
1628. Masses of Heavenly Bodies. *P. E. Shaw* 636
1629. Rotation Period of Markings on Jupiter. *W. F. Denning* 636
1630. Dimensions of Jupiter. *S. Chevalier* 636
1631. Prominent Markings on Jupiter. *S. Bolton* 636
1632. Heliocoidal Filaments of Comet Morehouse (1908*c*). *F. Baldet* 636
1633. Stellar Parallaxes. *S. A. Mitchell* 636
1634. Densities of Second-type Stars. *H. Shapley* 636
1635. Variability of S.S. Aurigae. *A. A. Nijland & van der Bilt* 637
1636. Classification of Stellar Spectra 637
1637. 637

LIGHT.

1638. Ruling of a Ten-inch Grating. *A. A. Michelson* 638
1639. Photoelectric Photometry by Null Method. *F. K. Richtmyer* 638
1640. New Method of Heterochromatic Photometry. *I. G. Priest* 638
1641. Physical Photometer. *W. W. Coblentz* 639
1642. Visibility of Radiation in Red End of Spectrum. *E. P. Hyde & W. E. Forsythe* 640
1643. Transmission of Red Pyrometer Glasses. *E. P. Hyde, F. E. Cady, & W. E. Forsythe* 640
1644. Optical Constants of Thin Layers of Silver. *H. Fritze* 641
1645. Reflecting Power of Metals in Ultra-violet. *E. O. Hulburt* 642
1646. Polarisation of Light scattered by Particles. *E. T. Paris* 642
1647. Magneto-optic Effect in the Ultra-red. *W. Voigt* 642
1648. Width of Spectral Lines. *A. J. Dempster* 642
1649–1650. 643
1651. Displacement of Spectral Lines not due to Pressure. *C. E. St. John & H. D. Babcock* 643
1652. Emission Centres in Flames. *H. Senftleben* 643
1653. New Line Series in the Spectrum of Helium. *J. Koch* 644
1654. Absorption Spectra of Vapours. *J. C. McLennan & E. Edwards* 645
1655. Series in Spectra. *H. G. Savidge & J. W. Nicholson* 645
1656. Series in Spectra. *W. M. Hicks* 646
1657. Spectra of Graphites. *J. Lunt* 646
1658. Pole Effect in Iron Arc. *C. E. St. John & H. D. Babcock* 646
1659. Dispersion of CO_2 in Infra-red. *C. Statescu* 647
1660. Infra-red Spectra. II. *N. Bjerrum* 647
1661. Infra-red Spectra of Gases. III. *N. Bjerrum* 647
1662. Reflection Spectra of Solutions in Infra-red. *F. Gehrts* 648
1663. Infra-red Emission Spectrum of Mercury Arc. *J. C. McLennan & R. C. Dearle* 648
1664. U.V. Spectrum of Silicon. *J. C. McLennan & E. Edwards* 649
1665. Spark Spectra in Extreme Ultra-violet. *L. & E. Bloch* 649
1666. 648

PAGE
1667. Effect of Electric Field on Spectrum Lines. V. and VI. *J. Stark* 649
1668. Stark-Lo Surdo Phenomenon in Helium. *R. Brunetti* 649
1669. Emission of Spectral Lines. *R. Ladenburg* 649
1670. Doppler-effect of Canal Rays in Argon. *K. Friedersdorff* 650
1671. Fluorescence produced by Ultra-Schumann Rays. *C. F. Meyer & R. W. Wood* 650
1672. Fluorescence of Iodine Vapour. I. *W. H. Westphal* 650
1673. Measurement of Surface Radiation Energy. *T. Christen* 651
1674. Absorption of Homogeneous X-radiation. *W. Kossel* 651
1675. Atomic Refraction. *A. Heydweiller* 651
1676. X-ray Photography, showing "Depth." *P. Knipping* 651
1677. Application of Se to Measurement of X-ray Energies. *R. Furstenau, F. Voltz* 652
1678. Phenomena observed when X-rays fall on Straight Edge. *J. Laub* 652
1679. Structure of some Crystals of Spinel Group. *S. Nishikawa* 652
1680. Passage of Light through Slit of Spectroscope. *P. Zeeman* 652
1681. Röntgen-patterns of Crystals. *H. Haga & F. M. Jaeger* 653
1682. Röntgen-patterns of Crystals. *H. Haga & F. M. Jaeger* 653
1683. Secondary Rays from Canal Rays. *H. Baerwald* 653
1684. Life of Radio-active Substances and Range of Rays. *F. A. Lindemann* ... 654
1685. Comparison of Radium Standard Solutions. *J. Moran* 654
1686. α-Particles from Thorium Active Deposit. *A. B. Wood* 655
1687. Ionisation Track of α-Rays. *J. C. McLennan & H. V. Mercer* 655
1688. Registration of α- and β-Particles. *J. E. Shrader* 655
1689. Velocity of β-Particles. *W. F. Rawlinson* 656
1690. β-Radiation from RaD. *L. Meitner* 656
1691. Penetrating Radiation at High Altitudes. *W. Kolhörster* 657
1692. D-radiation emitted by Zinc. *J. C. McLennan & C. G. Pound* 657
1693. Penetrating Radiation in Atmosphere. *A. Gockel* 658

HEAT.

1694. Thermal and Electrical Conductivities. *W. Meissner* 659
1695. Method of measuring Heat Conductivities. *R. W. King* 659
1696. Diathermancy of Liquids. *J. Vallot* 659
1697. Specific Heat and Plasticity of Metals. *F. Skaupy* 660
1698. Maximal Velocity of Evaporation of Mercury. *M. Knudsen* 660
1699. True Temperature of Solid Body. *E[lisabeth] Benedict* 660
1700. Theory of Fusion. *S. Ratnowsky* 661
1701. Electron Theory and Nernst's Formula. *K. F. Herzfeld* 661
1702. Internal Pressure of Gases; Influence of Pressure. *A. Leduc* 662
1703. Reflections on the Kinetic Theory. *E. Bouty* 662
1704. Equation of State Tested in the Vapour Dome. *H. N. Davis* 662
1705. Entropy in Condensed Substances. *S. Pagliani* 662
1706. Methods used in the Cryogenic Laboratory. *H. K. Onnes* 663

PAGE
1707. Heat of Copper between 14° and 90° K. *W. H. Keesom & H. K. Onnes* ... 664
1708. Isothermal of Hydrogen at 20° C. from 60 to 90 Atmos. *H. K. Onnes, C. Dorsman & G. Holst* ... 664
1709. Isothermal of Hydrogen at 20° C. from 60 to 100 Atmos. *H. K. Onnes, C. A. Crommelin & E. I. Smid* ... 664
1710. Quantum Theory. *A. Einstein* ... 665
1711. Law of Velocity Distribution. II. *E. Gehrcke* ... 665

SOUND.

1712. Speed of Sound in Crystals. *L. Hopf & G. Lechner* ... 666
1713. ... 666
1714. Effect of X-rays on Speed of Sound in Argon. *F. Strieder* ... 666
1715. Exploration over Telephonic Diaphragms. *A. E. Kennelly & H. O. Taylor* ... 666
1716. Sound Intensity. *H. Stiles & G. W. Stewart* ... 667
1717. Sound Speed in Gases. *K. Csukor* ... 667
1718. Simple Method for Sensitive Flames. *K. L. Schaefer* ... 667
1719. ... 667

ELECTRICITY AND MAGNETISM.

1720. Speed of Electrified Particles. *N. Bohr* ... 668
1721. Einstein's Photoelectric Equation. *R. A. Millikan* ... 668
1722. Elementary Electric Charge and the Photoelectric Effect. *D. Konstantinowsky* ... 669
1723–1726. ... 669
1727. Mobilities of Ions in Air. *J. C. McLennan & D. A. Keys* ... 669
1728. Mobility of Positive and Negative Ions. *H. A. Erikson* ... 670
1729. Ionic Mobilities in Hydrogen and Nitrogen. *W. B. Haines, A. M. Tyndall* ... 670
1730. Ionisation of Hydrogen by X-rays. *G. Shearer* ... 670
1731. Photoelectric Charging-up Potential. *E. Gehrcke & L. Janicki* ... 671
1732. Photo-electricity of Potassium. *G. Wiedmann* ... 672
1733. Photoelectric Effects. *F. Stumpf* ... 672
1734. Photoelectric Effects. *E. Wertheimer* ... 672
1735. Persistence of Current in Photoelectric Cells. *O. M. Corbino & G. C. Trabacchi* ... 673
1736. Electron Emission from Glowing Metals. *W. Schlichter* ... 673
1737. New Group of Electric Light Appearances. *E. Goldstein* ... 673
1738. Electric Light Effect. *K. Hermann* ... 673
1739. Critical Field at a Discharging Point. *A. M. Tyndall* ... 674
1740. Polarisation of Short Hertzian Waves by Metallic Gratings. *H. Behnken* 674
1741. Potential Curves for Röntgen Tubes. *A. Wehnelt* ... 674
1742. Photoelectric Cell as Receiver in Wireless Telegraphy. *H. Behnken* ... 674
1743. Electric Oscillations in Coupled Circuits. *W. H. Eccles & A. J. Makower* 675

PAGE
1744. Quenching in Spark-gaps. *H. Masing & H. Wiesinger* 675
1745–1746. 675
1747. Flow of Electricity through Dielectrics. *S. W. Richardson* 676
1748. Thermoelectric Properties of Carbon. *W. C. Moore* 676
1749. Piezoelectric Effect excited by Torsion. *W. Voigt & V. Freedericksz*...... 677
1750. 677
1751. Distributed Capacity of Solenoids. *J. C. Hubbard*.............................. 677
1752. A Case of Sine Vibration. *A. Kalähne* 678
1753. Simple Resonance Experiment. *O. Steels* 678
1754. Mechanical Model of Transmission Line. *F. Breisig* 678
1755. Lilienfeld's X-ray Tube. *F. J. Koch* 678
1756. Paramagnetic Determination and Energy at Absolute Zero. *R. Gans* ... 678
1757. Magnetic Quality as affected by Transverse Pressure. *W. J. Walker*...... 679
1758. Properties of Heusler Alloys. *E. Take & A. Semm*................................ 679
1759. Law of Susceptibility. *W. Steinhaus & E. Gumlich* 679
1760. Hall-effect in Bismuth Powder. *G. C. Trabacchi*................................ 680
1761. Magnetisation by Rotation. *S. J. Barnett*.. 680
1762. Susceptibility of Paramagnetic Substances. *R. Gans* 681
1763. Resistance of Graphite in Magnetic Field. *G. E. Washburn*................ 681
1764. 682
1765. Chronometric Methods for determining Earth's Field. *J. Andrade* 682
1766. Initial Magnetisation. *P. Weiss & J. de Freudenreich* 682
1767. Measurement of Hardness of X-rays. *F. Voltz*................................ 682
1768. Rapid Localisation of Projectiles. *T. Garraud*................................ 683
1769. Marion-Danion Method of Localisation. *Marion* 683
1770. Radiographic Localisation of Projectiles. *F. Ozil* 683

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1771. Density of Argon. *H. Schultze* 684
1772. Absorption of Air by Charcoal. *C. T. Knipp* 684
1773. Leakage of Gases through Quartz Tubes. *E. C. Mayer* 684
1774. Condition of Atoms in Crystals. *A. Johnsen*...................................... 684
1775. Loss of Weight of Musk. *C. B. Bazzoni*.. 685
1776. Penetration of Glass by Electric Sparks. *G. Quincke* 685
1777–1780. 685
1781. Dissociation Theory and Solid Solutions in Steels. *E. D. Campbell* 686
1782. Changes of Density produced by Annealing. *R. G. Parker & T. M. Lowry* 686
1783. Generation of Heat-hardened Steel. *C. F. Brush* 686
1784–1785. 687
1786. Potential of Rb Electrode. *G. N. Lewis & W. L. Argo*........................ 687
1787. Electrolysis of Solutions of Rare Earths. *L. M. Dennis & P. A. van der Meulen* 687
1788. Anodic Potentials of Silver. *J. H. Reedy* 688
1789. Measurement of Electrode Potentials. *A. W. Ewell* 688

AUTHORS' INDEX

Abbot, C. G., 1621, 1626.
Aldrich, L. B., 1621, 1626.
Andrade, J., 1765.
Andrus, C. G., 1619.
Argo, W. L., 1786.
Babcock, H. D., 1651, 1658.
Baerwald, H., 1683.
Baldet, F., 1632.
Barnett, S. J., 1761.
Barraduc-Muller, L., 1785.
Bazzoni, C. B., 1775.
Behnken, H., 1740, 1742.
Benedict, E[lisabeth], 1699.
van der Bilt, 1635.
Bjerrum, N., 1660, 1661.
Bloch, E., 1665.
Bloch, L., 1665.
Bohr, N., 1720.
Bolton, S., 1631.
Boussinesq, J., 1600.
Bouty, E., 1703.
Breisig, F., 1754.
Brunetti, R., 1668.
Brush, C. F., 1788.
Budde, E., 1604.
Burgess, G. K., 1780.
Byk, A., 1723.
Cady, F. E., 1643.
Camichel, C., 1601, 1602.
Campbell, E. D., 1781.
Chamberlin, T. C., 1623.
Chevalier, S., 1630.
Christen, T., 1673.
Chudeau, R., 1615.
Coblentz, W. W., 1637, 1641.
Corbino, O. M., 1735.
Crehore, A. C., 1779.
Crommelin, C. A., 1709.
Czukor, K., 1717.
Davis, H. N., 1704.
Dearle, R. C., 1663.
Dempster, A. J., 1648.
Denning, W. F., 1629.
Dennis, L. M., 1787.
Dodge, H. L., 1598.
Dorsman, C., 1708.
Eastman, E. D., 1780.
Eccles, W. H., 1743.
Edwards, E., 1654, 1664.
Ehrhardt, M., 1746.
Einstein, A., 1710.
Erikson, H. A., 1728.
Ewell, A. W., 1789.
Federlin, W., 1649.
Ferguson, A., 1611.
Forsythe, W. E., 1642, 1643.
Found, C. G., 1692.
Fowle, F. E., 1621, 1626.
Freedericksz, V., 1749.
de Freduenreich, J., 1766.
Friedersdorff, K., 1670.

Fritze, H., 1644.
Fürstenau, R., 1677.
Galitzine, B., 1595.
Gans, R., 1756, 1762.
Garraud, T., 1768.
Gehrcke, E., 1711, 1731.
Gehrts, F., 1662.
v. Geitler, J., 1650.
Gockel, A., 1693.
Goldhammer, D. A., 1614.
Goldstein, E., 1737.
Guillaume, E., 1606.
Gumlich, E., 1759.
Hadcock, A. G., 1596.
Haga, H., 1681, 1682.
Haines, W. B., 1729.
Hasegawa, K., 1622.
Hastings, C. S., 1619.
Hayford, J. F., 1625.
Hermann, K., 1738.
Herzfeld, K. F., 1701.
Heydweiller, A., 1675.
Hicks, W. M., 1656.
Hirsch, A., 1784.
Hobbs, W. H., 1616.
Holst, G., 1708.
Hopf, L., 1712.
Hubbard, J. C., 1751.
Hulburt, E. O., 1645.
Hyde, E. P., 1642, 1643.
Jaeger, F. M., 1681, 1682.
Janicki, L., 1731.
John, C. E. St., 1651, 1658.
Johnsen, A., 1774.
Kalähne, A., 1649, 1719, 1752.
Keesom, W. H., 1707.
Kennelly, A. E., 1715.
Keys, D. A., 1727.
Kimball, H. H., 1620.
King, R. W., 1695.
Knipp, C. T., 1772.
Knipping, P., 1676.
Knudsen, M., 1698.
Koch, F. J., 1755.
Koch, J., 1653.
Kolhörster, W., 1691.
Konstantinowsky, D., 1722.
Kossell, W., 1674.
Ladenburg, R., 1669.
Laub, J., 1678.
Lechner, G., 1712.
Leduc, A., 1702.
Leimbach, G., 1750.
Lewis, G. N., 1786.
Lindemann, F. A., 1684.
Livingston, B. E., 1618.
Lowry, T. M., 1782.
Lunt, J., 1657.
McCleland, N. P., 1778.
McLennan, J. C., 1654, 1663, 1664, 1687, 1692, 1727.
Makower, A. J., 1743.
Marion, 1769.
Masing, H., 1744.
Mayer, E. C., 1773.
Meissner, W., 1694.
Meitner, L., 1690.
Mercer, H. V., 1687.
van der Meulen, P. A., 1787.
Meyer, C. F., 1671.
Michelson, A. A., 1638.
Millikan, R. A., 1721.
Mitchell, S. A., 1633.
Moore, W. C., 1748.
Moran, J., 1685.
Muller, Barraduc-, L., 1785.
Nicholson, J. W., 1655.
Nijland, A. A., 1635.
Nishikawa, S., 1679.
Onnes, H. K., 1706, 1707, 1708, 1709.
Oppenheim, S., 1627.
Ozil, F., 1770.
Pagliani, S., 1705.
Palmer, A. H., 1617.
Paris, E. T., 1646.
Parker, R. G., 1782.
Paulson, E., 1666.
Pealing, H., 1777.
Pickering, E. C., 1637.
Priest, I. G., 1640.
Quincke, G., 1776.
Ratnowsky, S., 1700.
Rawlinson, W. F., 1689.
Reedy, J. H., 1788.
Reid, H. F., 1624.
Richardson, S. W., 1747.
Richtmyer, F. K., 1639.
St. John, C. E., 1651, 1658.
Sale, P. D., 1780.
Sano, K., 1622.
Savidge, H. G., 1655.
Schaefer, K. L., 1718.

Schenkl, E., 1605.
Schlichter, W., 1736.
Schultze, H., 1771.
Seeliger, R., 1603.
Semm, A., 1758.
Senftleben, H., 1652.
Shapley, H., 1634.
Shaw, P. E., 1628.
Shearer, G., 1730.
Shrader, J. E., 1688.
Skaupy, F., 1697.
Smidt, E. I., 1709.
v.Smoluchowski, M., 1609.
Stark, J., 1667.
Statescu, C., 1659.
Steels, O., 1753.
Steinhaus, W., 1759.
Stewart, G. W., 1716.
Stiles, H., 1716.
Strieder, F., 1714.
Strömberg, R., 1597.
Strong, W. W., 1726.
Stumpf, F., 1733.
Take, E., 1758.
Taylor, H. O., 1715.
Terazawa, K., 1608.
Trabacchi, G. C., 1735, 1760.
Tyndall, A. M., 1729, 1739.
Uller, K., 1607, 1610, 1724, 1725.
Vaillant, P., 1612.
Vallot, J., 1696.
Voigt, W., 1647, 1749.
Volterra, V., 1764.
Voltz, F., 1677, 1767.
Walker, W. J., 1757.
Washburn, G. E., 1763.
Wehnelt, A., 1741.
Weiss, P., 1766.
Wertheimer, E., 1734.
Westphal, W. H., 1672, 1713.
Wiedmann, G., 1732.
Wiesinger, H., 1744.
Wood, A. B., 1686.
Wood, R. W., 1671.
Yagi, H., 1745.
Zeeman, P., 1680.
Zenneck, J., 1613.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

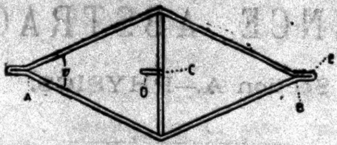
DECEMBER 1915.

GENERAL PHYSICS.

1595. *Apparatus for Direct Determination of Acceleration.* **B. Galitzine.** (Comptes Rendus, 161. pp. 281–283, Sept. 6, and pp. 304–308, Sept. 13, 1915.)—Describes an apparatus for the determination of the momentary value of the accelerations of the earth in seismological motions. On a base is mounted a stand whose upper end supports a heavy bob by a wire. This pendulum bob is held out so that its wire is at an angle with the vertical, the pressure of the bob being transmitted through a small strut on to a plate fixed on the stand. The change of pressure is directly proportional to the acceleration it is sought to measure. The plate is used to measure these pressures by the phenomena of piezo-electricity. E. H. B.

1596. *Longitudinal Strength of Cylinders closed by Screw Plugs.* **A. G. Hadcock.** (Roy. Soc., Proc. 92. pp. 1–8, Oct. 1, 1915.)—In designing the breech end of a gun, or the screwed end of a hydraulic cylinder, it has been generally assumed that the longitudinal stress is uniformly distributed over the cross-section of the gun-tube or of the cylinder when in action. In practice, however, the stress can rarely be applied uniformly over the section, and almost always acts either on the inner or on the outer circumferential surface. The stress on the material is therefore greatest on the surface where the force is applied; thence, owing to the fibres stretching and sliding longitudinally over each other, the stress is partly transmitted throughout the thickness of the cylinder. In the paper it is shown that in a cylinder there is, on the screwed end, a bending moment exerted on the material, in additition to the ordinary uniform longitudinal stress, and formulæ are found for determining the optimum length of the screwed part in a plug closing a cylinder subjected to internal pressure. J. W. T. W.

1597. *Best Form for Balance Beams.* **R. Strömberg.** (Ann. d. Physik, 47. 7. pp. 939–948, Sept. 3, 1915.)—The almost universally used form of balance beam is rhomboidal in shape, but there has been little research on the influence exerted by the angle of this rhomboid upon the mechanical properties of the beam. By comparing a number of beams made out of brass rod 1 mm. square and of the form shown in the Fig., the author has investigated the influence of the angle v on (i) the moment of inertia, (ii) the time of swing, and (iii) the stability (reciprocal of deflection caused by a load of 100 gm.). The three curves exhibiting the relations between these properties and the value of v show that a beam in which $v = 60^\circ$ has max. stability, while the moment of inertia and time of swing (which are found to rise at an increasingly rapid rate as v increases) are still low. The use of this form of balance is therefore strongly recommended, as equal stability can be secured with a far lighter beam than heretofore. The influence of the vertical stay was next investigated, and it was found that the change of ratio between the arms for different positions of the beam was much greater when this stay was of the same thickness as the rest of the framework of the beam than when it was of twice that thickness. In fact, it is concluded that the constancy of ratio in the latter case is as good as can be attained at any thickness, and this, therefore, is the proportion advocated.



J. W. T. W.

1598. *Effect of Heating on the Elasticity of Aluminium.* **H. L. Dodge.** (Phys. Rev. 6. pp. 312–318, Oct., 1915.)—This paper is the third of a series upon the effect of temperature on the elasticity of wires. The apparatus is the same as that used in previous work with copper and mild steel [see Abs. 376 (1914), 800 (1915)]. Tests were made upon two samples of Al-wire known commercially as "hard" and "soft," and the results obtained show that Al behaves similarly to other metals, except that hard Al-wire exhibits an almost constant temperature coefficient of elasticity. Annealing does not materially change the value of Young's modulus, but it does affect the rate of change, increasing the temperature coefficient of elasticity for low temperatures and decreasing it for higher values, the dividing temperature being about 100° C.

As a result of the work done up to the present, the following general conclusions are drawn as to the effect of temperature on Young's modulus for metals:—(1) By thorough annealing the metal can be brought to a cyclic state in which the modulus becomes a function of the temperature. (2) The modulus of the metal decreases with increase of temperature, the rate of change increasing with the temperature. (3) When the metal is heated by the passage of an electric current through it, the change in the modulus is a pure temperature effect. J. W. T. W.

1599. *Stress Distribution in Engineering Materials.* (Engineering, 100. pp. 379–380, Oct. 8, 1915. Paper read before the British Assoc. at Manchester. Engineer, 120. pp. 354–355, Oct. 8, 1915.)—The mild steel acquired by the Committee of the British Association for the study of this subject has the composition 0·182 % C, 0·028 % Si, 0·017 % S, 0·028 % P, and 0·800 % Mn. The results of preliminary tensile tests indicate the great influence of rolling, since the values obtained from different sizes of bars show very wide variations. This points to the necessity of adopting some method of annealing which will bring the material to a uniform molecular structure for all sizes of bars. The results of tensile bending and torsion tests on the material annealed at 900° C. are described in one appendix while another appendix contains the results of alternating-stress tests made by B. P. Haigh.

F. C. A. H. L.

1600. *Deducing the Amount of Fluid delivered by a Pipe which contains an Appreciable but Gradual Constriction.* **J. Boussinesq.** (Comptes Rendus, 161. pp. 258–264, Sept. 6, 1915. Lum. Élec. 30. pp. 304–306, Sept. 25, 1915.) —From the experimental work of Herschel, Camichel, Eydoux, and Lhériaud it has been established that the delivery by a pipe may be very simply deduced within an accuracy of 1 % from the difference between the two pressures which are exercised along the axis (supposed horizontal) of the section immediately before the constriction and along the axis of the most constricted portion. The pipe is supposed to posssess a prolonged and very gradual narrowing together with a complementary widening, so that there is neither abrupt deviation nor sensible curvature of the fluid elements. The necessary formula is obtained by applying D. Bernoulli's principle, and taking the average speed of the fluid elements across any normal section instead of their individual speeds. There are very appreciable differences between the speeds of fluid elements along the central axis and at the periphery which, however, grow less as the constricted section is approached. It appears somewhat paradoxical, therefore, that the hypothesis of speed equality should furnish a delivery which is practically exact, and the author attempts to show here how this paradox is explained by two small errors working in contrary directions. The latter are : neglect of friction and departures from perfect fluidity on the one hand, and the fact on the other that if speed inequality be taken into account the theoretical delivery obtained in the case of a perfect fluid will be greater than actually takes place. The present paper contains a mathematical investigation which establishes the formula giving the above excessive delivery when a perfect fluid and speed inequality of its elements are supposed. The accuracy of the previous experimental work is now confirmed within the limits of 1 %. H. H. Ho.

1601. *On Water-hammer in Pipes and Consequent Mass Oscillations.* **C. Camichel.** (Comptes Rendus, 161. pp. 343–345, Sept. 20, 1915.)—Previous work on water-hammer in pipes by Allievi, Boussinesq, Joukovsky, Rateau, de Sparre, etc., has been mainly theoretical. The author now gives the more important results of a preliminary experimental investigation into the subject. A pipe is first considered which possesses air-pockets having sufficient volumes to render negligible the compressibility of the liquid and the dilatation of the pipe. The oscillations of mass produced at the entrance and exit are very important, since resonance phenomena have frequently been observed in town water mains and in factory pipes. The case for a single air-pocket has been already investigated by Rateau, and the present author now extends the theoretical results to the general case of *n* pockets. Experimentally two pipes have been studied of 30 cm. diam. and 30 m. length, and 8 cm. diam. and 12·5 m. length, respectively. Rateau's result for the case of a single pocket at the lowest extremity of the pipe has been completely verified, namely, that the period of oscillation is proportional to the square root of the volume of the air-pocket. For two pockets, the graphs indicate two periods whose values agree with those deduced from the formulæ. For the experimental determination of the various points, the pipe is furnished at its extremity with a small valve driven by a motor whose speed can be varied whereby different resonances may be accurately established. The author promises to give data whereby the oscillation periods in a pipe may be determined as a function of the volumes of possible air-pockets and of their position, and these will indicate dangerous periods for the pipe.

H. H. Ho.

1602. *On Water-hammer in Air-free Pipes.* **C. Camichel.** (Comptes Rendus, 161. pp. 412–414, Oct. 4, 1915.)—The speed of propagation of a wave in a pipe is determined by abruptly opening a small valve placed at its extremity, and thereby causing a sudden diminution in pressure. The subsequent pressure-variations are registered by means of a manometer, and, from the pressure graph obtained, a very convenient determination of the speed of propagation of the wave may be made. During this determination the pipe studied remained closed while the compensation valves were also suspended from action. The experiments were conducted upon an iron pipe of 80 mm. diam., 5 mm. thickness, and 154·5 m. length. A very concordant series of experiments afforded a speed of 1280 m. per sec. Joukovsky and Allievi's formula, $a = 9900/\sqrt{(48{\cdot}3 + kd/e)}$, ($k = 0{\cdot}5$, $e =$ thickness, $d =$ diam. of pipe), furnishes a speed of 1815 m. This discrepancy between the two results may be attributed to the thickness of the pipe, the influence of which is not yet understood, to the recording apparatus, and above all to the fact that the formula has been shown by Boussinesq to be only applicable to thin pipes. Experiment has been found to agree with theory for the case of water. By means of a motor-driven valve, resonance has been produced as in the case of air-pockets being present, and stationary waves observed. Hereby the fundamental thrust, together with its second, third, fourth, and fifth harmonies have been observed. The methods given may be applied to industrial cases.

H. H. Ho.

1603. *The Method of Small Ocillations in Atomic Dynamics.* **R. Seeliger.** (Deutsch. Phys. Gesell., Verh. 16. 24. pp. 1042–1050, Dec. 30, 1914.)—In the Physics of the Atom founded on Maxwell's theory, the absorption and emission of electromagnetic waves by the atom are due to electrons capable of oscillating within the atom, whose motions give rise to the classical electrodynamical and mechanical laws. These electrons whether in static or dynamic equilibrium are bound by forces which in general are conservative, *i.e.* are endowed with a potential and vary as a function of their displacement. The usual method of investigation is to regard the latter as special linear functions, and on the theory of elasticity they become quasi-elastic forces. The analytical result is the linear equation of motion, $d^2x/dt^2 + \lambda_i^2 x_i = 0$, which is fundamental in atomic dynamics. The possibility of sharp spectral lines and the absence of harmonic super-oscillations, are a direct consequence of the linearity of the equations of motion. Two possibilities offer themselves on interpreting the latter: either the forces and equations of motion are independent of the amplitude, an assumption leading to the conception of Thomson's homogeneous positive spheres, or the linearity which is true for small amplitudes is solely an approximation to the true relationships. This latter gives rise to the method of small oscillations which the author here mathematically develops. From the Lagrangian equations of motion, if the amplitudes be small, the higher powers may be neglected in comparison with the first, and so linear equations result. Fallacious consequences can here be deduced ; although the author has on this assumption found no difficulties in connection with the dispersion theory and in magneto- and electro-optics, but opines that the linear forces must be critically examined from the standpoint of electrodynamic effects. It is essentially otherwise when Stark's discovery of the electrical splitting of spectral lines is taken into account. Since linear equations of motion show no influence on frequency by an external electric field, equations of a general type have to be accepted. Here a non-linear field of force is required, and the problem now depends on the applicability of the theory of small oscillations. Voigt showed that Stark's results may be obtained in their simplest essential features by means of nonlinear forces suitably chosen. In this theory Voigt likewise makes use of the method of small oscillations in the sense that he integrates the equations of motion restricted to their linear terms; the higher terms serve solely the purpose, in consequence of the central unsymmetry of the field of force, of producing differences in the frequencies of those small oscillations which appear as a splitting of the spectral lines. Nothing *a priori* can be brought against the assumption that the omissions made are permissible, if the oscillations of the electrons are sufficiently small, although much that is unsatisfactory remains, and the author believes the problem capable of further investigation. The present paper contains a preliminary attempt to this end, and, as the general case in three dimensions leads to very complicated expressions, the linear problem has been first attempted and is now presented. H. H. Ho.

1604. *A Critical Note on the Relativity Principle.* **E. Budde.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 586–612, July 15, and 16. 21. pp. 914–925, Nov. 15, 1914.)—A lengthy discussion of Einstein's earlier (1905) relativity principle. L. H. W.

1605. *On d'Alembert's Principle.* **E. Schenkl.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 650–667, July 15, 1914.)—The subject is dealt with in sections, of which one is devoted to the physical interpretation of the principle, another to the position of d'Alembert's principle with respect to Newton's axioms, whilst a third deals with a geometrical interpretation of d'Alembert's principle. The author claims for this latter interpretation several advantages. L. H. W.

1606. *The Theory of Probabilities and Physical Science.* **E. Guillaume.** (Archives des Sciences, 39. pp. 205–236, March, and pp. 301–323, April, 1915.)—The first two instalments of a general discussion on the theory. L. H. W.

1607. *Reflection and Refraction of Elastic Waves.* **K. Uller.** (Deutsch. Phys. Gesell., Verh. 16. 17–18. pp. 835–849, Sept. 30, 1914.)—Highly mathematical treatment. L. H. W.

1608. *On Deep-sea Water Waves caused by a Local Disturbance on or beneath the Surface.* **K. Terazawa.** (Roy. Soc., Proc. 92. pp. 57–81, Nov. 1, 1915.)—Treats, on H. Laub's method, the case in which the initial disturbing force is situated at a finite depth from the free surface. L. H. W.

1609. *Calculation of Brownian Motions by the Ehrenhaft-Millikan Experimental Arrangement.* **M. v. Smoluchowski.** (Phys. Zeits. 16. pp. 318–321, Sept. 15, 1915).—Mathematical treatment with special reference to the work of H. Fletcher. [See Abs. 1652 (1911) and 884 (1915).] E. H. B.

1610. *Fluid Motions under Vibrational Stimulus.* **K. Uller.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 818–819, Aug. 30, 1914.)—Highly mathematical treatment based on the relation between the velocity field and the density field. E. H. B.

1611. *Drop-weight Method for determining Surface-tensions.* **A. Ferguson.** (Phil. Mag. 30. pp. 632–637, Oct., 1915.)—The author gives a critical discussion of a few of the more important methods of measuring surface tension. He has previously pointed out (Science Progress, p. 428, Jan., 1915) that only those methods which are quite independent of contact-angle can safely be employed, and consequently the results obtained by the use of the capillary-rise method were of very variable value. During recent years the drop-weight method has been brought to a very high state of accuracy as regards its practical details by J. L. R. Morgan, who has determined in this way the surface-tensions of more than 100 pure organic liquids. The author now examines the question as to whether or not this method gives results which are independent of the contact-angle, and discusses the relation between the drop-weight and capillary-rise methods from this standpoint. A. B. W.

1612. *On the Laws of the Flow of Liquids in Drops.* **P. Vaillant.** (Comptes Rendus, 161. pp. 384–387, Sept. 27, 1915.)—The laws previously given [see Abs. 818 (1915)] can be deduced from the general law: The weight p of the drops is a parabolic function of the frequency of fall N, of the form $p = a\mathrm{D} + m\beta\mathrm{N} - n\gamma\mathrm{N}^2/d$, where m and n are whole numbers, m having the values 1 or 2, n the values 1, 2, or 4; β and γ are two constants independent of the tube and characteristic of the liquid, and a is also a coefficient characteristic of the liquid but which increases slightly as D diminishes. In the case of water in the neighbourhood of 20°, $\beta = 4{\cdot}20$, $\gamma = 0{\cdot}0157$. N represents the number of drops in 100 secs., and p is the weight of one drop in hundred-thousandths of a gm. When D varies between 2 mm. and 7 mm., a varies between about 1600 and 1400. From the experimental numbers, we may conclude that the values of m and n are determined by the external diam. D. When D is less than about 5 mm., $m = 1$ with $n = 1$. When D is greater, $m = 2$ with $n = 4$ if the internal diam. is small, $n = 2$ if it is greater than 1 mm. It appears also that the coefficient a, instead of varying continuously with D, has two distinct values: one in the neighbourhood of 1570 when $m = 1$, the other in the neighbourhood of 1420 when $m = 2$. In the case of wider tubes, as the drops become larger they tend more and more to undergo vibration by the detachment of the preceding drop, and the results obtained become more and more irregular. A. F.

1613. *Demonstration and Photography of Currents in Liquids.* **J. Zenneck.** (Deutsch. Phys. Gesell., Verh. 16. 14. pp. 695–698, July 30, 1914.)—Oak sawdust has been used to show the currents inside liquids, but these give diffuse reflections. The present author uses small gas-bubbles blown in at one end of a glass trough of the liquid; the other end receives the light of an electric arc, while the camera is placed at one side. Photographic reproductions are given showing the impact of a current on different obstacles. E. H. B.

1614. *Quantum Theory and Molecular Structure.* **D. A. Goldhammer.** (Deutsch. Phys. Gesell., Verh. 16. 14. pp. 707–718, July 30, 1914.)—On the basis of the work of Planck, N. Bjerrum, H. A. Lorentz, P. Ehrenfest, and Eva v. Bahr, the author calculates atomic (ρ) and molecular (R) radii as follows:—

	O	N	Cl	I	C	H	Br
$\rho \times 10^8$	0·671	0·705	0·900	1·135	0·882	0·560	1·016

	NO	CO	ICl	HCl
$R \times 10^8$	1·376	1·453	2·035	1·460
	1·307	1·439	2·068	1·504

[See Abs. 1954 (1913), 456 (1914).] E. H. B.

1615. *Atmospheric Pressure and Rainfall in Western and Equatorial Africa.* **R. Chudeau.** (Comptes Rendus, 161. pp. 351–354, Sept. 20, and pp. 392–395, Sept. 27, 1915.)—Monthly and annual values of atmospheric pressure are given for 13 stations from 27° N. to 4° S. latitude. The most northerly of these show a maximum of pressure in Jan. and a minimum in July. In the neighbourhood of the Equator the principal maximum is in July or Aug., the minimum in April or May. The diurnal variation is well marked, and is shown nearly every day. Depressions are very rare. The main features of the normal distribution of pressure in different months are described. In the second article mean annual rainfall totals are given for a number of stations from 17° N. to 4° S. latitude, derived from observations continued from 5 to 21 years. They vary from 190 mm. at Timbuctoo to 4627 mm. at Conakry.

Vapour pressure in the neighbourhood of the Equator has a mean value of about 20 mm. of mercury. Further north the pressure diminishes in the interior of the continent, and on occasion approaches zero. In the Sahara vapour pressure depends mainly upon the origin of the air brought by the wind, and local evaporation comes only into the question during the two or three days following rain. R. C.

1616. *The Rôle of the Glacial Anticyclone in the Air Circulation of the Globe.* **W. H. Hobbs.** (Am. Phil. Soc., Proc. 54. pp. 185–225, Aug., 1915.)—In earlier papers the theory of fixed glacial anticyclones centred over the snow and ice masses of Greenland and Antarctica has been put forward by the author, and in the present communication the theory is examined in the light of the results of recent exploration. The author considers that the old generally accepted theory of polar cyclones with westerly currents blowing around them, first put forward by Ferrel, is now rendered entirely untenable. He finds that the wind observations which are available for high latitudes, both north and south, are far more in conformity with the supposition of glacial anticyclones and winds blowing almost radially out from them. His theory is that the cold ice surfaces cause cooling of the superimposed air and consequent increase of pressure. This cold air then commences to slide down the ice surfaces from the high plateaus to the sea with accelerating velocity. This leads to the strong winds experienced in blizzards. After a time the velocity may increase to such an extent that the cooling on the ice surface is overpowered by the adiabatic warming of compression, and this föhn effect leads to a sudden rise of temperature and cessation of the strong wind. These strong winds would not occur at the centre of the anticyclone; and reference is made to the fact that Amundsen on his South Polar expedition entered, near the 88th parallel, a region which appeared to be one of permanent calms or light winds; and a similar condition was found by de Quervain in the central plateau of Greenland. Recent pilot balloon ascents made both in Greenland and Antarctica show that the outward-flowing surface winds are balanced by inwardly directed currents at great heights, and thus the old theory of circumpolar whirls does not account for the conditions even in the upper levels of the air. It is suggested that the permanent anticyclones prohibit the passage of depressions across the ice masses, and that stationary "lows" are located where these barriers oppose a progressive movement. J. S. Di.

1617. *Region of Greatest Snowfall in the United States.* **A. H. Palmer.** (Monthly Weather Rev. 43. pp. 217–221, May, 1915.)—Though there may be a greater average seasonal snowfall in some of the uninhabited and unstudied portions of the United States, no region from which records have been obtained has shown higher values than the Sierra Nevada of California. Throughout many square miles of this region more than 100 in. of unmelted snow falls every winter. Notwithstanding this heavy fall the snow disappears even from the highest peaks in May or June, and usually does not reappear until October. Some maximum winter snowfalls, which totalled up to 65 ft., have been recorded. At Tamarack (8000 ft.) the average depth of snow on the ground at the end of March, deduced from 9 years' records, is 16 ft. There are great difficulties in the way of obtaining accurate measurements of snowfall, but the problem is simplified in the region under discussion by the fact that winds are mainly light. Various types of apparatus for measuring snow depths and snow densities are described. The paper is illustrated with many photographs showing the conditions which prevail in the district in winter.
J. S. Di.

1618. *The Measurement of Evaporation.* **B. E. Livingston.** (Monthly Weather Rev. 43. pp. 126–131, March, 1915.)—Until recently little attention has been devoted to the accurate measurement of the rate of evaporation of water into the atmosphere, and no standardised form of atmometer has been in general use. It is pointed out that different types of instruments will give dissimilar results, and, further, that if a reduction factor be deduced to reduce the readings from one instrument to harmony with those from another type, this factor will have a different value for every different type of weather conditions that may prevail. To take one instance, the ratio of the readings from two instruments may be quite different on a windy day and a calm day. This points to the extreme desirability of standardising so far as possible the type of instrument used. On the other hand, certain variations of type may be necessary on account of the different purposes for which the measurements may be made. Thus to measure the rate of loss of water from reservoirs the floating pan type of atmometer is probably the most suitable. Where the study involves the measurement as it affects plant transpiration, the use of some form of porous clay surface from which the evaporation takes place is preferable. It is from this latter point of view that the author approaches his subject, and a detailed description and illustration of the type of atmometer favoured by him is given. In the most recent form of this instrument a spherical cup of porous clay, 5 cm. in diameter, is mounted above a bottle, from the contents of which it is automatically kept filled with water. The loss of water by evaporation is then determined, either by weighing, if great accuracy is required; or a simple reading of the amount the water-level has fallen in the bottle will be sufficient for ordinary work. As the result of experience it has been found possible to make the porous cups with little variation in their individual factors. Numbers of this type of instrument have been brought into use in the last few years, so that comparable results are now being obtained by many different workers. J. S. Di.

1619. *Solar Halo of May* 11, 1915. **C. G. Andrus.** (Monthly Weather Rev. 43. pp. 213–214, May, 1915.)—An unusual display of prismatic arcs was observed near the sun on May 11, 1915, at Sand Key, Florida, among clouds of cirro-stratus type moving eastwards. Rough instrumental measurements indicated the presence at various times of arcs of radius 22°, 28–29°, 18°, 17–18°, 8–9°. In the colouring of the arcs it was noted that the red was on the side nearest the sun, so that in the halo-curves and the parhelion the red was on the inner circumference of the arc, while in the circumzenithal arc the red was on the outer circumference of the curve. **C. S. Hastings.** (Ibid. pp. 215–216, May, 1915.)—A solar halo showing very vivid colouring was observed at New Haven on May 20, 1915, between 11.30 a.m. and noon, the sun's altitude being 68° or over. Owing to the relative darkness of the area within the ring, it was considered that it was not the well-known 22° halo, but the "Oval of Venturi," formed by the upper and lower tangent arcs of the 22° halo uniting when the altitude of the sun is sufficiently great. If this were so, the horizontal diam. should be greater than the vertical diam., and the upper and lower portions brighter than the eastern and western portions. Both these criteria were confirmed by the observations, and also by a most fortunate photograph obtained by C. N. York, using a lens of 9·5 in. focal length working at *f*/3. The plate was exposed for 1/100 sec. behind a 15-times filter, and developed with pyro-soda. A fragment of the 46° circle was also observed below the sun. In explanation it is stated that the appearance was due to ice crystals in the form of elongated hexagonal prisms with bases at right angles to their axes, the prisms falling with axes horizontal, and at the same time rotating about these axes. The oval would then be produced by refraction through two alternate faces of the prism whenever a crystal at about 22° from the sun happened to present itself in a favourable position.
C. P. B.

1620. *Total Radiation on a Horizontal Surface from the Sun and Sky at Washington.* **H. H. Kimball.** (Monthly Weather Rev. 43. pp. 100–111, March, 1915.)—An account of the Callendar recorder and the methods of observation adopted at Mount Weather has already been given [see Abs. 400 (1915)]. The results of similar measurements made at Washington, D.C., are set out fully in the present paper in four tables. Some of the more important features are also illustrated by diagrams. The results for Washington and those previously obtained at Mount Weather have been combined for obtaining normal values. It is to be noted that in the annual curve of total daily radiation the maximum is found to occur in May with a secondary maximum in July. It is significant that the diurnal range of temperature reaches its maximum in May, at the time that the solar and sky radiation reaches its maximum, while the quantities both reach their minimum values in December. Isopleths of radiation are given for Washington showing the variations from hour to hour and from month to month. J. S. Di.

1621. *Solar Constant of Radiation.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Nat. Acad. Sci. Washington, Proc. 1. pp. 331–333, June 15, 1915. Monthly Weather Rev. 43. pp. 212–213, May, 1915.)—Upwards of 1000 determinations of the solar constant have been made by the spectrobolometric method, giving a mean value of 1·93 cals. per cm.^{2} per min. The bolometric measurements have been reduced by comparisons on each day with standardised pyrheliometers. The atmospheric transmission coefficients obtained at Mt. Wilson agree very closely with Rayleigh's theory of atmospheric scattering, except for those spectral regions where numerous atmospheric lines and bands of true absorption are known to occur, and the determinations of number of molecules per cm.^{3} of air at standard temperature and pressure agree with Millikan's determinations by independent observations and methods. Observations at Mt. Wilson and Bassour (Algeria) agree in showing a decided irregular variability from day to day. These results have been criticised as being too small owing to a miscalculation of the atmospheric transparency at various zenith distances; but this is not accepted by the authors, who discuss the matter elsewhere at length [Abs. 1626 (1915)]. Further evidence has been obtained by a recording pyrheliometer attached to a sounding balloon which on July 11, 1914, ascended to a height of 24 km., good records being secured for more than an hour. The mean value after correction is given as 1·88 cals.

C. P. B.

1622. *On the Wave produced by the Sudden Depression of a Small Portion of the Bottom of a Sea of Uniform Depth.* **K. Sano** and **K. Hasegawa.** (Math. Phys. Soc. Tōkyō, Proc. 8. pp. 187–199, Sept., 1915.)—On June 15, 1896, an earthquake occurred at Miyako in N.E. Japan. The sea retired and a great wave rolled in, followed 7 mins. later by the greatest wave of a series. After the arrival of the second remarkable crest, great waves rolled in successively for nearly 2 hours and then damped slowly. The authors, for the purpose of mathematical investigation, assume the tidal wave to have been produced by a sudden downfall at the bottom of the sea; sea-water is likewise considered as a perfect incompressible fluid whose motion is irrotational, while the sea-bottom is supposed to be a horizontal plane and unlimited in direction. With these limitations the following interesting results are obtained:—(1) The calculated time-interval between the beginning of the earthquake and the first crest is roughly equal to that observed. (2) The calculated time-interval between the beginning of the earthquake and the second crest is not so greatly different from the observed one. (3) Among all the crests the second has the greatest height above the sea-level even for the calculated and observed values. (4) After the second crest the waves damp slowly for both values. (5) From the table the discrepancy between the calculated and observed values is explained by taking an idea of natural oscillation into consideration. The authors opine that a cause of tidal waves is originated by a fault at the epicentre. Whatever values be ascribed to t (time), r (distance between Miyako and the epicentre), h (mean depth of the sea at Miyako and the epicentre), and g (gravity), the value of η (elevation of the free surface) remains the same so long as r/h and $t = \sqrt{(g/h)}$ are both kept constant.

H. H. Ho.

1623. *Geological Theory of Earth's Interior.* **T. C. Chamberlin.** (Am. Phil. Soc., Proc. 54. pp. 279–289, Sept., 1915.)—Interchanging opinion between geologists and other scientists has of late years gradually tended to the abandonment of the old theory of a molten earth, and an approach to the conviction that the earth is essentially solid. A study of the stress-conditions of the interior also suggests a similar reversal of former inferences drawn from the igneous rocks. Accepting the geological evidence for the compressive forces which at repeated intervals have produced the mountain ranges, high plateaus, and deep-sea basins, the extrusions which apparently took place at the times of great diastrophism do not appear to be in any way commensurate with the stresses implied. There is, further, an absence of evidence that the lavas in craters and volcanic rocks are parts of great liquid masses below. Preliminary discussion of recent investigations of tidal studies and seismic waves also appear to favour the idea of an elastico-rigid earth. A *résumé* is given of the possible bearing of the planetesimal theory in furnishing data compatible with the new ideas. It is suggested that gravitational isostatic adjustments may take place in a highly rigid elastic earth without resort to flowage. C. P. B.

1624. *Seismological Evidence of Structure of Earth's Interior.* **H. F. Reid.** (Am. Phil. Soc., Proc. 54. pp. 290–297, Sept., 1915.)—After tracing the gradual recognition of the three types of seismic wave (longitudinal, transverse, and surface), some account is given of the determination of velocities in different directions as bearing on the evidence concerning the nature of the earth's interior structure and density. Special attention is devoted to the core and concentric shell theories of Wiechert and Gutenberg, and to the experiments on earth deformation originated by G. and H. Darwin in 1879, and more recently carried out in different ways by Rebeur Paschwitz, Hecker, Orloff, and Michelson. A noteworthy feature is that the rigidity is found to be greater in an east–west than in a north–south direction. The general conclusion is that the transmission of transverse seismic waves indicates that the earth is solid, at least to a great depth below the surface, and that deflection experiments show that it is as rigid and viscous as steel. C. P. B.

1625. *Geophysical Study of Earth's Structure.* **J. F. Hayford.** (Am. Phil. Soc., Proc. 54. pp. 298–308, Sept., 1915.)—General outline of the isostatic view of the structure of the earth, giving reasons for the desirability of a new series of computations on the lines of those made by Darwin and Love, but adapted to the real land distribution instead of hypothetical continental surfaces. C. P. B.

1626. *Intensity of Solar Radiation outside the Atmosphere.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Misc. Collections, 65. 4. pp. 1–55, June 19, 1915. Nature, 96. p. 296, Nov. 11, 1915. Abstract.)—Owing to the value of 1·93 cals. per cm.^{2} per min. for the solar constant as determined by the authors having been criticised in certain quarters as being too small, new evidence is collected to show reason for believing this estimate to be very nearly correct. It is shown that on fine days at Mt. Wilson there is no observable systematic change of atmospheric transparency from sunrise to 10 a.m., and that even at 24 km. altitude the intensity of solar radiation is less than 1·9 cals. per cm.^{2} per min. An interesting account of the automatic recording pyrheliometer attached to the balloons is given, with a reproduction of one of the charts obtained. C. P. B.

1627. *Plane of the Solar Motion.* **S. Oppenheim.** (Astron. Nachr. No. 4818. Nature, 96. p. 209, Oct. 21, 1915. Abstract.)—Ephemerides of 265 minor planets were used to determine the mean motions of the bodies in every two hours region of R.A., which on reduction by the Bessel-Kobold method gives values of the node and inclination of the earth's orbit. The elements of the solar motion were then obtained by Charlier's method. C. P. B.

1628. *Masses of Heavenly Bodies and the Newtonian Constant.* **P. E. Shaw.** (Nature, 96. pp. 143–144, Oct. 7, 1915.)—The author questions the accuracy of the conclusion usually drawn from Kepler's third law as to the same value of the gravitational constant (G) applying to the sun and all planetary bodies. Argument is dependent mainly on the variation of G with temperature, which the author finds to be 1 unit in 10^5 for 1 deg. C. In the case of astronomical calculations no error arises from this because in general the product of mass × gravitational constant is used. C. P. B.

1629. *Rotation Period of Markings on Jupiter.* **W. F. Denning.** (Roy. Astron. Soc. of Canada, J. Sept., 1915. Nature, 96. p. 154, Oct. 7, 1915. Abstract.)—Details are given of measurements of the rotation period of the Great Red Spot and the Hollow in the southern equatorial belt, the calculations embracing the 84 years, 1831–1914. During this time the period seems to have varied from 9h. 55m. 33·8s. to 9h. 55m. 41·7s. A marked acceleration has been noted since 1910. C. P. B.

1630. *Dimensions of Jupiter.* **S. Chevalier.** (Mem. Soc. Spettroscop. Ital., July, 1915. Nature, 96. p. 154, Oct. 7, 1915. Abstract.)—Visual and photographic measures of the diameter of Jupiter have been made at the Zô-Sé Observatory during 1912–13. The results were for the polar diam., visual 35·37″, photographic 35·20″; equatorial diam., visual 38·16″, photographic 37·99″. Flattening factor found about 1/13·6. C. P. B.

1631. *Prominent Markings on Jupiter.* **S. Bolton.** (Nature, 96. p. 172, Oct. 14, 1915.)—Details are given of recent observations (Sept., 1915) with a 26-in. reflector of the principal markings on Jupiter, the South Tropical Disturbance, and the Red Spot Hollow. The former marking is more than 90° in length, and first appeared in 1901. The length of the Hollow is about 33°, practically the same as it has been throughout the last 15 years. C. P. B.

1632. *Helicoidal Filaments of Comet Morehouse* (1908*c*). **F. Baldet.** (Comptes Rendus, 161. pp. 272–275, Sept. 6, 1915.)—The author has in previous communications called attention to the helicoidal structure of certain parts of the tail matter of Comet Morehouse [Abs. 33 (1909); 1663 (1911)]. The investigation is developed on the lines of the forms taken by the kathode discharge in a magnetic field. C. P. B.

1633. *Stellar Parallaxes.* **S. A. Mitchell.** (Astrophys. J. 42. pp. 263–270, Oct., 1915.)—Results are given of the first series of stellar parallaxes determined by photography at the Leander McCormick Observatory, University of Virginia, using the 26-in. Clark refractor. The photographs were made on Cramer isochromatic plates through a yellow colour-filter. Details are given for 70 Ophiuchi (0·145″); 6 Cygni (0·051″). C. P. B.

1634. *Densities of Second-type Stars.* **H. Shapley.** (Mt. Wilson Solar Observatory, Contrib. No. 107. Astrophys. J. 42. pp. 271–282, Oct., 1915.)—Evidence is given for the view that there are in existence solar-type stars of remarkably low density, so low that for masses comparable to that of the sun their volumes must be hundreds of times greater than it. The argument is presented in the form of a single relation giving the upper limit to the mean density of an eclipsing binary without any hypothesis as to the depth of the minima or the relative size or brightness of the components. C. P. B.

1635. *Variability of S.S Aurigæ.* **A. A. Nijland and van der Bilt.** (Astron. Nachr. No. 4814. Nature, 96. p. 179, Oct. 14, 1915. Abstract.)—This is one of four variables discovered by Silbernagel in 1907, and belongs to the class of long-period irregular variables, of which U Germinorum is the type. The magnitudes recorded vary from 10·7 to 14·7. C. P. B.

1636. *Classification of Stellar Spectra.* (Observatory, No. 492. pp. 379–392, Oct., 1915. Discussion before the British Assoc. at Manchester.)—Starting with the classification introduced by Secchi, **A. Fowler**, in opening the discussion, traced the gradual development of the study of stellar classification through the modifications introduced in the comprehensive Draper Catalogue of the Harvard observers (based on the stellar spectra only), the Kensington classification (based on the study of the stellar spectra in intimate conjunction with the laboratory spectra of the various elements under widely varied conditions), and the sequence proposed by Russell from the study of stellar magnitudes, masses, and densities. The various schemes range themselves around two main points: (*a*) stellar evolution as a continuous progression from nebulæ to red stars; (*b*) as a progression from a cool body to a very hot stage, followed by a subsequent decline to invisibility.

The discussion ranged chiefly in connection with details of Russell's theory, in favour of which appears to be the existence of certain stars of widely differing densities, whose spectra are practically identical. On the other hand, it introduces difficulties with regard to the accepted relationships between the various spectral classes. There is also great difficulty in allocating positions in the present classifications to the planetary and other nebulæ. Atomic theory calculations indicate that Wolf-Rayet spectra are later than those of nebulæ. C. P. B.

1637. *Radiometric Measures of* 110 *Stars.* **W. W. Coblentz.** (Bureau of Standards, Bull. 11. pp. 613–656, 1915.)—A more complete account of the work dealt with in Abs. 540 (1915).

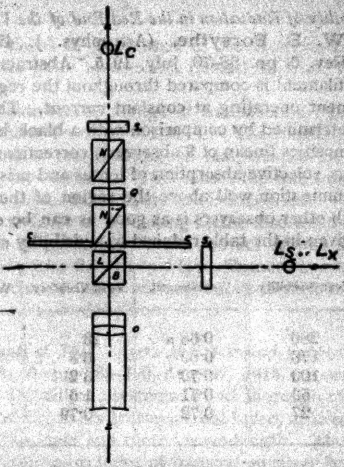
LIGHT.

1638. *Ruling and Testing of a Ten-inch Diffraction Grating.* **A. A. Michelson.** (Am. Phil. Soc., Proc. 54. pp. 137–142, May–July, 1915.)—In the endeavour to obtain gratings of very high resolving power, rulings have been made by the author on plates of greater dimensions than those used by Rowland, and in the present paper he describes the performance of a 10-in. plane grating. In the notes concerning the production of the grating it is stated that the screw was cut in a specially corrected lathe so that the original errors were not large, and these were reduced by long grinding with very fine material until they were sufficiently small to be automatically corrected during the process of ruling. An interesting novelty was in the application of interference methods to the measurement and correction of the residual errors, the tests being made to twentieths of a light-wave (about one-millionth of an inch). The determined corrections for periodic errors were transferred to the worm-wheel turning the screw of the dividing engine, and those for errors of run to the nut moving the carriage. The slides guiding the grating carriage and those controlling the motion of the ruling diamond were corrected by an auto-collimating device until their deviations from straight lines were less than one second of arc. Friction of the grating carriage was diminished to about one-tenth that due to weight by partial flotation on mercury. The nut actuating the carriage had bearing surfaces of tin instead of wood as in previous machines. A copy of a photograph made with a 10-in. grating, 6th order, 11,700 lines to the inch, is reproduced. The negative shows a resolving power of 600,000, the theoretical value being 660,000. A short discussion is given of the possibility of obtaining gratings of still greater resolving power by means of stationary waves from a homogeneous light-source. C. P. B.

1639. *Photoelectric Photometry by Null Method.* **F. K. Richtmyer.** (Phys. Rev. 6. pp. 66–68, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—The apparatus consists of two similar alkali-metal photoelectric cells arranged after the manner of a Wheatstone bridge with two sources of potential, e_1 and e_2, the connected ends of which are of opposite polarity. The place of the galvanometer is taken by a sensitive electrometer, and the values of e_1 and e_2 are adjusted by trial, so that the dark currents through the cells are balanced as shown by the null reading of the electrometer. Two sources of light are now compared by placing them so that each illuminates one cell and then adjusting their respective distances from the cells until there is again no deflection on the electrometer. If the relation between these distances be plotted a straight line results, showing that the two cells used obey exactly the same current illumination law of the form $C = kI^x$, where C is the photoelectric current, I the illumination, and x an exponent whose probable value is unity. The preliminary observations show that differences of illumination of 0·01 % are measurable. J. W. T. W.

1640. *New Method of Heterochromatic Photometry.* **I. G. Priest.** (Phys. Rev. 6. pp. 64–66, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—The method is best understood from the Fig., in which

L_c is a comparison lamp, L_s a standard, and L_x the lamp to be measured. S_1 and S_2 are opal glass screens, L-B a Lummer-Brodhun cube, and O an eyepiece. N is a fixed Nicol prism, and Q a right-handed quartz plate with its optic axis along the line of sight ZZ. N′ is a nicol which can be rotated about ZZ, the amount of rotation being measured by a divided circle, C. To make a measurement, Q is taken out and replaced by a homogeneous glass plate, while N′ is set at 90° from the position of extinction. L_s and L_c are then balanced by moving L_s along XX. L_s is then replaced by L_x, and Q is put back in ZZ. By moving L_c, and at the same time turning N′, a complete match both of colour and intensity is obtained, and it has been found that a quartz plate 1 mm. thick will yield a perfect colour-match between carbon and tungsten lamps. From a knowledge of the specific rotation of quartz (α_λ) for all values of the wave-length (λ), a curve can be plotted expressing $V_\lambda \cos^2 (\phi - \alpha_\lambda t)$ as a function of λ, V_λ being the relative visibility of light of wave-length λ, ϕ the rotation of N′, and t the thickness of Q. If S represents the ratio of the area of this curve to that of the visibility curve, then the candle-power of L_x is given by I_sRTS, where I_s is the c.p. of L_s, R is the inverse square ratio of the two positions of L_c, and T the transmission of Q relative to the glass plate. The computation can be much simplified by the preparation of permanent tables giving TS as a function of λ. J. W. T. W.



1641. *Physical Photometer in Theory and Practice.* **W. W. Coblentz.** (Frank. Inst., J. 180. pp. 335–348, Sept., 1915.)—The author discusses the suggestion that a bolometer or thermopile, screened by a solution which transmits such rays as to give a luminosity curve identical with the eye, should be used as a photometer. Particulars of several solutions proposed for this purpose are given, and some experiments therewith are described. It is pointed out that the absorption of some regions in the infra-red presents difficulties, and that concentration of solution and thickness of cell are not interchangeable for radiation of this character. In order to overcome this difficulty and to suppress the infra-red element, the solution giving a luminosity curve identical with that of the eye and an added depth of water were used in separate cells. The transmission throughout the spectrum of a special "luminosity-curve" solution, and of solutions of copper sulphate, potassium dichromate, and cobalt ammonium sulphate are shown by diagrams. A linear thermopile with the "luminosity-curve" solution was applied to test the absorption of other solutions, and also to compare the intensity of a glow-lamp with that obtained by ordinary photometric methods. An agreement within 0·2 % was reached in this experiment.

J. S. D.

1642. *Visibility of Radiation in the Red End of the Visible Spectrum.* **E. P. Hyde** and **W. E. Forsythe.** (Astrophys. J. 42. pp. 285–298, Nov., 1915. Phys. Rev. 6. pp. 68–70, July, 1915. Abstract.)—The spectrum of a broad carbon filament is compared throughout the region 0·63 to 0·77 μ with a second filament operating at constant current. The energy curve of the first lamp is determined by comparison with a black body. In reducing the observed luminosities (mean of 9 observers) corrections are made for dispersion, slit-widths, selective absorption of lenses and prism, and care was taken to keep the illumination well above the region of the Purkinje-effect. The agreement with other observers is as good as can be expected. The results obtained are given in the table reduced to a visibility of 100 at 0·65 μ.

Wave-length.	Mean Visibility.	Wave-length.	Mean Visibility.	Wave-length.	Mean Visibility.
0·63 μ	280	0·68 μ	13	0·73 μ	0·39
0·64	170	0·69	6·3	0·74	0·19
0·65	100	0·70	3·2	0·75	0·09$_5$
0·66	53	0·71	1·6	0·76	0·04$_5$
0·67	27	0·72	0·79	0·77	0·02$_0$

J. W. T. W.

1643. *Transmission of Red Pyrometer Glasses.* **E. P. Hyde, F. E. Cady,** and **W. E. Forsythe.** (Astrophys. J. 42. pp. 294–304, Nov., 1915. Phys. Rev. 6. pp. 70–75, July, 1915. Abstract.)—It has long been recognised that the breadth of the transmission band of a so-called monochromatic pyrometer filter leads to a change in the effective wave-length of transmission with any change in the spectral distribution of the incident radiation due to alteration of temperature of the radiating source. The importance of knowing the effective wave-length (*i.e.* the wave-length for which, for any definite temperature interval, the ratio of the radiation intensities in that wave-length is equal to the ratio of the integral luminosities through the filter) led the authors to the present investigation on a double thickness (5·8 mm.) of red glass, probably Jena "Rotfilter" No. F–4512. Two methods were used (1) direct measurement, (2) computation, assuming the visibility curve of the eye. The source used was a glow-lamp run at two arbitrary currents corresponding to temperatures of 1600° and 2000° K. By the first method the ratios of the emission intensities at these two temperatures for a number of wave-lengths were measured with the ratio of the integral luminosities observed through the filter. By the second method the integral luminosities through the filter at the two chosen temperatures were computed from a knowledge of the spectral energy curves, the transmission curve for the filter, and the sensitivity curve of the eye [see preceding Abs.].

The results obtained by these methods agree in giving 0·664 ± 0·001 μ as the effective wave-length between the above-given temperatures. The change of this wave-length with change of temperature interval was the subject of further experiment, the results obtained being shown in the table below :—

Temperature Interval.	Effective Wave-length.	Temperature Interval.	Effective Wave-length.
1336–1600°	0·664$_9$ μ	1822–2400°	0·662$_9$ μ
1600–1822°	0·664$_1$	2400–3100°	0·661$_7$

Observations on other pieces of glass used in the Holborn-Kurlbaum and other pyrometers indicate quite appreciable deviations from the particular specimen used above.

Observations were made on the change of transmission due to alteration of temperature of the filter from 20° to 81° C. The transmission is found to decrease with increase of temperature, the temperature-coefficient being greatest in the shortest wave-lengths. This causes the transmission band to shift to longer wave-lengths as the temperature is increased.

The influence of the position of a rotating sector-disc when used with the Holborn-Kurlbaum type of pyrometer is the subject of one section of the paper, and it is found *inter alia* that when a lamp filament is used as a source the orientation of the sector openings with reference to that of the filament produces a marked effect on the definition. J. W. T. W.

1644. *Optical Constants of Thin Layers of Silver and Copper.* **H. Fritze.** (Ann. d. Physik, 47. No. 6. pp. 763–790, Aug. 17, 1915. Extract of Inaug. Dissertation, Breslau.)—Describes a systematic and thorough research on the dependence of the optical constants of transparent layers of silver and copper upon the thickness of the layer and on the wave-length. The chief results are as follows :—(1) The refractive index of transparent silver layers decreases steadily with increased thickness in the region investigated, 0·6–105 $\mu\mu$, while the absorption coefficient increases, though not to the same extent. Both constants approximate for a certain limiting thickness to the values for the solid metal, as determined by Drude's reflection method. Layers of thickness 105 $\mu\mu$ and upwards may be called massive metal layers. For copper the dependence of the constants on the thickness of the layer is not so decided as for silver. (2) Silver and copper layers show with all thicknesses abnormal or normal dispersion corresponding to that characteristic of the massive metal. (3) Silver layers, whether obtained chemically or by kathodic deposition, are characterised by the same values of the optical constants for the same wave-length and thickness. This consideration, in conjunction with (2), points to the conclusion that the layers obtained by both methods have the same constitution. (4) The Hagen-Rubens method of determining the absorption coefficient of transparent metal layers does not lead to the correct value, although the absorption coefficient determined by this method is a function of the thickness. (5) Comparison of the results obtained by using Kundt's prism method with Försterling's theory shows that for Ag and Cu layers Kundt's method does not give the correct value for the refractive index. The discrepancies noted are too large to be due to experimental errors. The author's results for copper layers are in good general agreement with those recently obtained by Planck [Abs. 1677 (1914); see also Abs. 89 (1911)]. A. W.

1645. *Reflecting Power of Metals in Ultra-violet.* **E. O. Hulburt.** (Astrophys. J. 42. pp. 205–230, Oct., 1915.)—Direct measurements of the reflecting powers of six metals (silver, gold, platinum, copper, nickel, steel) were made by Hagen and Rubens in 1902, the results being tabulated as far as $\lambda 2500$ [Abs 452 (1902)]. So far as is known no other results have been published going further to the ultra-violet until the present paper, which gives details of the examination of 28 metallic mirrors of different composition, the curves of reflecting power being drawn for the region $\lambda 1800$ to $\lambda 3800$. It is noteworthy that for light of wave-length shorter than $\lambda 3800$ silicon is the only metal showing a reflecting power much greater than 50 %. For the investigation light from a strong source of ultra-violet rays was analysed in a small concave grating of 50 cm. focal length, and approximately monochromatic light emerging from a secondary slit was examined by means of a photoelectric cell and electrometer, both direct and with reflection from the surface under test. The curves plotted from the readings are given for all the metals examined. C. P. B.

1646. *Polarisation of Light scattered by Small Spherical Metal Particles.* **E. T. Paris.** (Phil. Mag. 30. pp. 459–481, Oct., 1915.)—A solution of the problem of the scattering of electromagnetic waves by a spherical obstacle has been given by Love. Rayleigh has shown [Abs. 1728 (1910)] that Love's results admit of considerable simplification, and has used the simplified forms to calculate the polarisation of the scattered wave when light is incident on a transparent sphere having a refractive index of 1·5, and of dimensions comparable with the wave-length. In the present paper an account is given of the calculation of the polarisation of the light scattered by spherical particles whose circumferences measure between one and two wave-lengths; first, on the supposition that the particles are perfect electrical conductors, and secondly, for the case of silver particles immersed in water, the incident light having a wave-length of 550 $\mu\mu$. Observations have been made on the polarisation of the light scattered by silver suspensions containing particles of known size. The behaviour indicated by the theory is followed except when the circumference of the particles approaches two wave-lengths. In this case the theory indicates some remarkable changes in the polarisation which have not been observed in any experiment. A. W.

1647. *Magneto-optic Effect in the Ultra-red for Iron and Cobalt.* **W. Voigt.** (Phys. Zeits. 16. pp. 298–306, Aug. 15, 1915.)—A theoretical treatment of the law of dispersion of the magneto-optic effect in the ultra-red for Fe and Co, based on the experimental results of various investigators. From the observations of Ingersoll on the equatorial Kerr-effect, it can be shown that for steel and Co the magneto-optic behaviour in the wave-length region of about $2\,\mu$ is conditioned principally by the conducting electrons. Applying the results to the Lorentz theory, a value is obtained for the internal magnetic field of the order of 10^7, while the external field is of the order $2{\cdot}5$ to $1{\cdot}4 \times 10^4$. The high internal field leads again to the conclusion that in the ferromagnetic metals there exist molecules or molecular complexes with very strong magnetic polarity, which through the external fields maintain a tendency to parallelism. The order of magnitude of the closed internal fields of Weiss obtained from this idea agrees with that deduced from the magneto-optic effect. A. W.

1648. *Width of Spectral Lines.* **A. J. Dempster.** (Ann. d. Physik, 47. 6. pp. 791–808, Aug. 17, 1915.)—Electronic excitation of a Wehnelt kathode shows that the collisions are not elastic, and the structure of complicated lines is not simplified. Moreover, for a large range of velocities of the exciting electrons the light vibrations are quite homogeneous.

In the quartz mercury lamp the chief component of the green line is broadened more than the satellites, whilst the broadening of the helium lines by the oscillatory discharge is generally similar to the Stark-effect, although here absorption can exert an influence.

With a weak condenser discharge the green mercury line is broadened by pressure of helium gas more than is to be expected from the Stark-effect. H_α, under similar pressure, is less broadened than Michelson has found using hydrogen gas pressure, and although the width of this line agrees with that reckoned on the assumption of unit mass, H_β and H_γ are much too broad. By using fast kathode rays as excitants, it is possible to obtain $\lambda = 4686$ Å.U. sharply defined and to make exact interferometric measurements.

The crediting of lines to a specific atomic weight is uncertain so long as the sources remain undiscovered. Why, for instance, should H_β and H_γ be more broadened by pressure than H_α, although all three lines are certainly emitted by the same centre? C. S. G.

1649. *Daguerreotypes by Cadmium Vapour.* **A. Kalähne** and **W. Federlin.** (Deutsch. Phys. Gesell., Verh. 16. 21. pp. 981–983, Nov. 15, 1914.)—Describes the method and appends a faint reproduction of a full-length figure. E. H. B.

1650. *Theory of Resonance Radiation.* **J. v. Geitler.** (Deutsch. Phys. Gesell., Verh. 16. 14. pp. 688–694, July 30, 1914.)—From the standpoint of the theory of coupled systems the author considers that true resonance radiation can only be said to arise when, with monochromatic illumination, a vapour emits light only of the same colour as the light falling on it (isochromatic resonance). [See Abs. 1527 (1914).] A. W.

1651. *Displacement of Spectral Lines not due to Pressure.* **C. E. St. John** and **H. D. Babcock.** (Phys. Rev. 3. pp. 487–488, June, 1914. Abstract of paper read before the Am. Phys. Soc., April, 1914.)—Examination of the light from different portions of an iron arc shows that there are variations in the wave-lengths of the lines depending on the portion of the arc examined. Difficulties are found in securing non-simultaneous exposures which are not affected by minute instrumental variations, and to avoid these arrangements were made to obtain simultaneous exposures on regions near the pole and the centre of the arc. These photographs show certain groups of lines for which there is no shift between the centre and the negative pole, while others show shifts which would indicate a pressure-difference of more than 1 atmo. if pressure were the cause. Discussion of the various groups suggests that this is not the prevailing factor, and it is suggested that the effect may be due to variations of density. A table is given showing the shifts determined for selected groups of lines. C. P. B.

1652. *Emission Centres in Flames.* **H. Senftleben.** (Ann. d. Physik, 47. 7. pp. 949–1000, Sept. 3, 1915. Dissertation, Breslau.)—Describes research on the number of the emission centres of metal vapours in luminous flames, and the connection between this number and the brightness of the spectrum given out. The magnetic rotation of the plane of polarisation in luminous

Na-vapour was determined with the greatest possible precision for the D lines. Comparison of the three hitherto possible methods gave the following results :—The method of crossed nicols is not suitable for exact measurements, although for a small range of measurement it yields to a certain degree accurate results. The method in which double wedges of quartz are employed also permits of no very great accuracy of measurement, and only allows of research at such distances from the absorption lines for which the rotation varies so much with the wave-length that the results (obtained with a grating in the third order and with the narrowest possible slit) show a marked dependence on the spectral resolution. The method of Savart's plates is free from these objections, though it permits of measurements being made at a greater distance from the absorption lines, and it is also capable of giving highly accurate results. (1) Using this method the author was able to establish Voigt's theory of the magnetic rotation of the plane of polarisation for points not too close to the absorption lines. (2) According to this theory the magnitude $\rho = 4\pi N e^2/m$, where N is the number of emission centres per unit volume, is to be determined. For the greatest and least vapour densities employed the following values were obtained : $\rho_{D_1} = 332{\cdot}5 \times 10^{21}$, $\rho_{D_2} = 680{\cdot}5 \times 10^{21}$; $\rho_{D_1} = 2{\cdot}46 \times 10^{21}$, $\rho_{D_2} = 5{\cdot}17 \times 10^{21}$. For a density between the greatest and least the values $\rho_{D_1} = 116 \times 10^{21}$, $\rho_{D_2} = 250 \times 10^{21}$ were obtained. These correspond to values of $N_{D_1} = 3{\cdot}76 \times 10^{13}$ and $N_{D_2} = 8{\cdot}1 \times 10^{13}$ respectively. (3) The connection between the brightness of the flame and the number of emission centres was investigated quantitatively, and the law deduced theoretically by Ladenburg and Reiche, that with constant and not too small vapour density the brightness is proportional to the square root of the number of emission centres was well established. (4) Absorption measurements allowed the dependence of the flame brightness on the number of emission centres to be determined, also for very small vapour densities. Combining the results obtained from the absorption measurements with those of (3) above, the number of emission centres for very small vapour densities, for which direct measurements of the magnetic rotation of the plane of polarisation was impossible, could be determined. (5) Measurements of the brightness and the number of luminous particles for several flame temperatures showed that a variation of flame temperature of only 1·5 % gave rise to a variation of the number of emission centres of as much as 25 %. (6) The ratio of the numbers of emission centres for the two D-lines was found, with an accuracy of a few per cent., to equal 2, and this ratio showed little variation with the vapour density or the flame temperature within the range employed. [See also Abs. 2040 (1907), 1555 (1914).] A. W.

1653. *New Line Series in the Spectrum of Helium.* **J. Koch.** (Ann. d. Physik, 48. 1. pp. 98–108, Sept. 28, 1915.)—Using a field of about 100,000 volts/cm. a strong new line of wave-length $\lambda 452\,\mu\mu$ was found in the He spectrum. Later investigation showed that the line was not due to any impurity, and, moreover, it was found that the intensity of the line depended on the strength of the electric field employed. The weaker the field the fainter was the line, and in the absence of any field it disappeared altogether. It appears also that the position of the line is dependent on the field strength, the displacement being proportional to the field strength. A second new line was found at $\lambda 405\,\mu\mu$. The displacement of this line is 1 Å.U. for a field of 17,000 volts/cm., that of the line $\lambda 452\,\mu\mu$ being 1 Å.U. for 65,000 volts/cm. The two lines are members of a difference series of the Ritz type, and the formula for the frequency is $\nu = (2, p, \pi) - (m, p, \pi)$, where $m = 3, 4, 5 \ldots$, and p and π are the series constants for the principal series. The following are the calculated and observed wave-lengths :—

Calc................	6068·85	4518·65	4046·30	3880·05
Obs.	6060	4518·77	4046·02	—

It is interesting to note that both the new lines are strongly polarised, and the component parallel to the field is much stronger than the perpendicular component. A. W.

1654. *Absorption Spectra of Mercury, Cadmium, and Zinc Vapours.* **J. C. McLennan and E. Edwards.** (Phil. Mag. 30. pp. 695–700, Nov., 1915.)—The absorption spectra of non-luminous mercury and zinc vapours have been examined, using a large Hilger quartz spectrometer, the light sources being the Henri aluminium spark, the zinc spark, and the mercury arc. With the exception of the mercury band at λ2338 Å.U., all the absorption bands found for Hg and Zn by the authors, as well as those found for non-luminous Cd-vapour by Wood and Guthrie, are the first members of either of the series represented by $\nu = 1{\cdot}5, S - m, P$ and $\nu = 2, p_2 - m, S$.

The complex mercury band at λ2338 Å.U., which appears at high densities, and which has not been shown as yet to belong to any series, consists of a band extending from λ2318 to 2320 Å.U., bands at λ2322 and 2326, and a wider one between λ2330 and 2338 Å.U. It is possible that corresponding bands have not been found for Zn and Cd owing to the vapours not being sufficiently dense. The spectroscopic investigation showed that specially pure doubly-distilled zinc still contained traces of mercury and cadmium.

C. S. G.

1655. *Calculation of Series in Spectra.* **H. G. Savidge and J. W. Nicholson.** (Phil. Mag. 30. pp. 563–568, Oct., 1915.)—Series in spectra are usually isolated by the spectroscopist as the result of a preliminary search throughout the spectra for pairs and trios of lines whose distances apart, when expressed in wave numbers, are constant. If such trios or pairs can be found, there is usually a probability that they are successive members of two interlacing series, one of the diffuse and one of the sharp type, whose calculated limits should be identical. But in practice spurious doublets and triplets—the result of chance—find their way into the list, and cause the necessary calculations to be very long and tedious. When the components of a series form doublets, moreover, one member of the doublet is usually very much weaker than the other, and often too weak to be seen and measured. One of the authors has recently shown that this is the underlying cause of the apparent non-existence of series in an important group of chemical elements, which actually contain series of the usual type, so that the laws of spectra are in all probability of a universal application. This work has not yet been published. Graphs are sometimes useful for testing the probability of lines belonging to a particular series, but the ensuing verification by a tedious calculation is always necessary. The need for a table has always been urgent, and has now been calculated by Savidge. It has the advantage of being applicable equally to the ordinary arc series with Rydberg's constant N and to the enhanced-line type of series discovered by Fowler in which this constant is 4N. It can also be applied to series in which this constant may be any other multiple of N. In series spectra developed in the arc the wave number n of a line is given very closely by the formula $n = A - N/(m + \mu)^2$, where A is the limit of the series, N is Rydberg's constant 109679·2, μ is Rydberg's parameter, and m takes integral values. If n_1 and n_2 are the wave numbers of two successive lines—

$$n_2 - n_1 = \mathrm{N}\,[1/(m+\mu)^2 - 1/(m+1+\mu)^2].$$

Let x denote the value of $(m+\mu)$ for the first line. Then—

$$n_2 - n_1 = \mathrm{N}[1/x^2 - 1/(x+1)^2],$$

or $x^2(x+1)^2/(2x+1) = \mathrm{N}/(n_2 - n_1)$. This is a biquadratic equation, from which, on the supposition that the two lines are successive members of a series, the value of x or $(m+\mu)$ for the first line can be obtained. The next member is then $n_3 = n_2 + \mathrm{N}[1/(x+1)^2 - 1/(x+2)^2]$, which can be calculated at once and compared with observation. Savidge's table gives the solution of this biquadratic for values of $a = \mathrm{N}/(n_2 - n_1)$ ranging from 1·8 to 80, and it is suitable for direct interpolation. When a is greater than 80 the formula $x = (2a)^{1/3} - \frac{1}{2} + \frac{1}{6}(2a)^{-1/3}$ may be used with a sufficient degree of accuracy. Illustrations of the use of the table are given. A. W.

1656. *Calculation of Series in Spectra.* **W. M. Hicks.** (Phil. Mag. 30. pp. 784–787, Nov., 1915.)—Savidge and Nicholson have recently published [see preceding Abs.] a paper on the calculation of series in spectra, occasioned by a supposed difficulty in testing for series and in calculating the formula constants. The author here points out that the usual method of testing for series is really quite simple, requiring about 20 minutes' work, including verification, to obtain all the constants involved. An explanation of the method adopted is given, and is illustrated by an example. A. W.

1657. *Spectra of Graphites and Lead Pencils.* **J. Lunt.** (Observatory, No. 492. pp. 399–401, Oct., 1915.)—With reference to a former paper in which the author had doubted the silicon origin of a spectrum line at λ4103 [Abs. 1417 (1914)], it is now admitted that from a new series of photographs, including the prominent Si line at λ3905·7, the evidence for regarding λ4103 as due to Si is quite satisfactory. The lead-pencil spectra now show not only λ3905·7, but also the strong lines in the red at λλ6347 and 6371. From the fact that the spectrum indicates lines of about 17 elements it is suggested as a useful comparison spectrum for unknown light-sources. C. P. B.

1658. *Pole Effect in Iron Arc.* **C. E. St. John** and **H. D. Babcock.** (Mt. Wilson Solar Observatory, Contrib. No. 106. Astrophys. J. 42. pp. 231–262, Oct., 1915.)—With the great increase of accuracy attained during recent years in the measurement of spectra taken with high dispersion, it has become needful specially to investigate numerous variations of wave-length of the lines which had been adopted for standards of comparison. The divergent results in the case of the iron arc were found to depend upon the arc-length, current density, and location in the arc from which the comparison is taken, and are chiefly prominent in those lines which exhibit more or less dissymmetry under varying pressure and line intensity [Abs. 654 (1914)]. Reliable results were only obtained by taking simultaneous exposures on the different parts of the arc by means of specially arranged reflecting prisms on the spectrograph slit. The shifts of lines at the arc pole vary for different lines, and are not dependent on changes of density or temperature between 2100° and 2600° C. Except in a few cases the pole effect disappears *in vacuo*, and does not appear to be related to the luminosity-differences between positive and negative poles. Between λ2979 and λ6678, of 1570 lines examined 286 show displacements to the red, and 80 to the violet. Tables are given showing details of the lines examined. C. P. B.

1659. *Dispersion of CO_2 in the Infra-red.* **C. Statescu.** (Phil. Mag. 30. pp. 737–748, Nov., 1915.)—A direct method of measurement was adopted, using a prism of the gas between plates of rock-salt. Results are given for wave-lengths ranging from the sodium D-lines to 18·19 μ. Taking the mean value for $(n - 1)$ as 0·0004508 for Na light, deduced from the results of Ketteler, Mascart, etc., this number decreases till at $\lambda 4{\cdot}0\,\mu$ it is $0{\cdot}000289_5$. At $\lambda 5{\cdot}0\,\mu$ it is $0{\cdot}000581_6$ and then decreases. Analysis of the curves shows the existence of an absorption band at $\lambda 4{\cdot}27\,\mu$, and a tendency towards another at about 14·7 μ. It is known that CO_2 shows anomalous dispersion at 2·715 μ, 4·270 μ, and 14·7 μ, but the presence of an absorption band between 2 and 3 μ could not be detected. It may be that since the first two bands are very near one another, the very marked band at 4·27 μ obscured the other. A. W.

1660. *Infra-red Spectra.* II. *Direct Measurement of Energy Quanta.* **N. Bjerrum.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 640–642, July 15, 1914.)—From the relationship, $\nu = nh/2\pi^2 I$...(1), which the author has already developed between the rotational frequency ν, the moment of inertia I, and Planck's constant h, n being a whole number integer, it follows that there must exist between the bands a constant frequency-difference equal to $h/2\pi^2 I$. This has been found by Rubens and Aschkinass for water-vapour and by Eva v. Bahr [Abs. 463 (1914)] for hydrochloric acid bands. Taking the latter molecule as a simple case, the author calculates its moment of inertia from the equation $E = RT/N = \frac{1}{2} I (2\pi\nu)^2$, where E is the rotational energy of the molecule at $T = 291°$, R is the gas constant, and N Avogadro's constant. He uses the value $\nu = 1{\cdot}87 \times 10^{12}$, derived from v. Bahr's exact measurements, 3·40 μ and 3·55 μ for the double band at 3·5 μ. On subsituting the value so obtained in equation (1), a very good agreement is obtained between the calculated values of ν and those observed by v. Bahr, n having the successive values 1–7. From this agreement the author concludes that the rotational energy of the HCl molecule is actually $= nh\nu$, and that Ehrenfest's and Eucken's modification of (1) to $\nu = nh/4\pi^2 I$ is not valid. C. S. G.

1661. *Infra-red Spectra of Gases.* III. *Configuration of the Carbon Dioxide Molecule and Laws of the Intramolecular Forces.* **N. Bjerrum.** (Deutsch. Gesell., Verh. 16. 15. pp. 737–753, Aug. 15, 1914.)—An important theoretical paper dealing with the connection between the infra-red absorption bands of the CO_2 molecule (2·7, 4·3, and 14·7 μ) and its intramolecular forces, oscillations, and rotations. The three bands correspond to three different but interdependent oscillations of the atoms. The atom masses are, following Rutherford, concentrated into three nuclei. In the first analysis all the internal forces are regarded as central forces between these three points, whilst in the second method of treatment central forces are presumed to exist between carbon and oxygen only, and not between the two oxygen atoms. Instead, between the oxygen atoms a tensional force is taken as being present, following O. v. Baeyer's valency strain theory, which alters the value of the angle θ, subtended at the carbon atom by the oxygen atoms. Each of these two postulations leads to two solutions which are discussed, at some length, in the light of the chemical and optical behaviour of the gas. The paper closes with the details of the mathematical treatment used in working out the solutions discussed in the earlier part. C. S. G.

1662. *Reflection Spectra of Solutions in the Infra-red.* **F. Gehrts.** (Ann. d. Physik, 47. 8. pp. 1059–1088, Sept. 14, 1915. Extract from Dissertation, Berlin.)—The paper reviews the results of similar work on solid salts and some saturated solutions by Pfund [see Abs. 1562 (1906)], Morse, Coblentz, Clark, and Porter. Water has been re-examined over the region 1·0–11·5 μ, and the results agree well with those found by Rubens and Ladenburg and by Ångstrom. Saturated solutions of silver nitrate, cadmium sulphate, and potassium chromate give maxima which are shifted towards longer wave-lengths to the extent of 0·1 to 0·4 μ as compared with the maxima of the solid salts. The influence of concentration was tested with ammonium nitrate and ammonium sulphate solutions. The relationship is not linear, since the reflection grows stronger with increasing concentration. Further, with decreasing concentration the maxima shift towards shorter wave-lengths, and both of these results agree with the Drude dispersion theory. Specific reflection maxima are found also with aqueous solutions of the metallic salts of organic acids, comprising potassium and ammonium thiocyanates, postassium, ammonium, and sodium formates, and potassium and sodium acetates, and in general ethereal salts (methyl thiocyanate and ethyl formate) show similar specific maxima. C. S. G.

1663. *Infra-red Emission Spectrum of the Mercury Arc.* **J. C. McLennan** and **R. C. Dearle.** (Phil. Mag. 30. pp. 683–695, Nov., 1915. Paper read before the Roy. Soc. of Canada, May 26, 1915.)—Previous investigations of the infra-red emission spectrum of mercury have led to somewhat conflicting results, and the present work has been carried out with the object of clearing up discrepancies. An Heraeus quartz mercury lamp was used in conjunction with a Hilger infra-red spectrometer, a Rubens thermopile, and a Paschen galvanometer. Considerable difficulty was experienced with the drifting of the zero and with mercury drops condensing on the lamp walls, but an accuracy of 0·01 μ is claimed for the readings. The results obtained are compared with those of previous workers. Thirteen lines are recorded between 1·00 and 3·02 μ, and their relative intensities are estimated. Lines found at 1·04 and 3·32 μ correspond with disputed lines at 1·038 and 3·00 μ found by Coblentz and Greer, whilst three previously unindicated lines exist at 1·067, 1·090, and 1·270 μ. The authors point out that the frequency-differences for the lines 1·038, 1·270, and 3·02 μ are the same as those which characterise the triplets in the subordinate series for the Hg arc spectrum given by $\nu = 2, p - m, d$, and $\nu = 2, p - m, s$. Further, it is suggested that possibly lines at 1·09 and 1·376 μ are the third and second members of a similar triplet with its first member, as yet unrecorded, in the neighbourhood of 3·70 μ. C. S. G.

1664. *Ultra-violet Spectrum of Elementary Silicon.* **J. C. McLennan** and **E. Edwards.** (Phil. Mag. 30. pp. 482–484, Oct., 1915. Paper read before the Roy. Soc. of Canada, May, 1915.)—Crookes [Abs. 1835 (1914)] has given the wave-lengths of lines in the spark spectrum of elementary silicon down to λ2125. The present paper contains a list of 17 lines ranging from λ2125 down to λ1842. The wave-lengths were determined by comparison with Zn and Al spark lines. The spectrograms were compared also with the spark spectrum of iron to make sure that no iron lines were included. No samples of Ti (a possible impurity) were at hand, but the high degree of purity of the Si used, and the fact that the spectrum came out on the plates when different pieces of the metal and different points on the same pieces were used as sparking terminals, would seem to guarantee the purity of the spectrum observed. A. W.

1665. *Spark Spectra in the Extreme Ultra-violet.* **L. and E. Bloch.** (Journ. de Physique, 4. pp. 622–637, Aug.–Sept., 1914.)—The spark spectra of iron, cobalt, nickel, arsenic, antimony, tin, bismuth, aluminium, cadmium, and silver have been examined photographically between λ2100 and λ1850 A.U., using a quartz spectrograph in air and long exposures on plates prepared according to Schumann's formula. Many new lines are recorded. The intensities can only be estimated qualitatively owing to the profound modifications occasioned by the absorption of the air. The results are compared with former measurements. C. S. G.

1666. *Spectra of Ruthenium, Niobium, and Thulium.* **E. Paulson.** (Phys. Zeits. 16. pp. 352–354, Oct. 1, 1915.)—Tabulated results. L. H. W.

1667. *Effect of Electric Field on Spectrum Lines.* V. and VI. **J. Stark.** (Ann. d. Physik, 48. 2. pp. 193–209, and pp. 210–235, Oct. 14, 1915.)—V. A continuation of previous work [Abs. 1071 (1914)] dealing with the fine resolution of the lines of the hydrogen series. Tables and diagrams are given of the various components. It is shown that the series lines of hydrogen are separated by an electric field into a large number of *p*- and *s*-components. The relative distance and the intensity ratio differ from line to line. The resolution throws light on the structure of the hydrogen atom, and it appears that in the hydrogen atom we are concerned with only a single electron which by its acceleration relative to a positive nucleus gives rise to the emission of the series lines.

VI. This paper deals with the polarisation and strengthening of the series lines of lithium. The experimental work was concerned only with the third subordinate series of lithium. Tables and diagrams are given of the electric separation of the components, showing how this depends on the field strength. Particulars are also given of the polarisation effects. A decided increase in intensity was observed as the fields employed were increased. This phenomenon has also been observed by Koch [see Abs. 1654 (1915)] for lines of a new helium series. The latter part of the paper discusses the origin of the series dealt with. A. W.

1668. *Stark-Lo Surdo Phenomenon in Helium.* **R. Brunetti.** (N. Cimento, 10. pp. 34–40, July–Aug., 1915.)—Owing to the varying results obtained by Stark and by Lo Surdo in studying the spectrum of hydrogen, the author has applied Lo Surdo's method to helium, which has been already investigated by Stark [Abs. 238, 1071 (1914)]. The results of the observations indicate the value of Lo Surdo's method and lead to the following conclusions:—Various lines of the He spectrum undergo decomposition, the latter being non-symmetrical with reference to the fundamental line. Certain lines present a satellite in the direction of short wave-lengths, this being a decomposition element detached from the principal line at the commencement of the electric field and showing increasing displacement as the kathode is approached. The displacements of the decomposition elements and that of the satellite do not obey the same law. The lines of the third diffuse accessory series are not decomposed into the same number of components. These results differ qualitatively and quantitatively from those of Stark.

T. H. P.

1669. *Atoms concerned in Emission of Spectral Lines.* **R. Ladenburg.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 765–779, Aug. 30, 1914.)—A mathematical discussion which reaches the following result :—Let H be energy emitted per sec. from an oscillator of frequency ν when in an enclosed space of specific intensity of radiation K of the same temperature and frequency. Then, in the present work, by various independent ways, accordant values are found for the ratio H ÷ K which is held to be a universal constant.

In the case of an electron as oscillator this value is—

$$C = 8\pi^2 e^2/mc = 0{\cdot}67[\text{cm.}^2/\text{sec.}].$$

From Gouy's measures on sodium flames, it follows from the above determination that out of 100 Na-atoms about 40 electrons are concerned in the emission of the D line. [See Abs. 2040 (1907), 58 (1909).] E. H. B.

1670. *Doppler-effect of Canal Rays in Argon.* **K. Friedersdorff.** (Ann. d. Physik, 47. 6. pp. 737–762, Aug. 17, 1915. Inaug. Dissertation, Halle.)—Describes research on similar lines to that of Stark and Kirschbaum [Abs. 1960 (1913)]. The results obtained by Stark and Kirschbaum for argon in the region λ4800 to λ4000 have now been established for a large number of lines extending from λ4965·4 to λ2884·1. The lines of the red Ar-spectrum have singly-charged atomions for carriers, the carriers for the blue spectrum being doubly or multiply charged. Between the particles carrying these charges of various values there exists by neutralisation or ionisation, a state of equilibrium. The number of the singly-charged atomions for the displaced line decreases with increased potential. At 42,000 volts the number is nearly zero. At 30,000 volts, besides the lines which have not as yet been arranged in series, those of series C and D (Rydberg's arrangement) are strongly emitted. At the higher potentials employed evidence was obtained of the existence of quadruply-charged atomions in addition to those doubly and triply charged, but the allocation of the lines to the various carriers cannot be accomplished with certainty. A. W.

1671. *Further Study of the Fluorescence produced by Ultra-Schumann Rays.* **C. F. Meyer** and **R. W. Wood.** (Phil. Mag. 30. pp. 449–459, Oct., 1915.) —The authors have carried out further experiments with the radiant emission from the spark [see Abs. 1987 (1914)], which had not been previously detected. The fluorescence produced by this radiation in nitrogen containing about 1 % of oxygen, in moistened nitrogen, in dry and moist air, and in nitrogen with an admixture of iodine vapour have now been photographed and examined. Special effects are obtained with moving streams of gas and an explanation of these is advanced.

Fluorite and crystalline quartz are slightly transparent to the rays, but those exciting the fluorescence of the water band pass more easily through fluorite than do those which excite the nitrogen bands, whilst for crystalline quartz the reverse is probably true. Certain of the rays are capable of producing a faint fluorescence in purified nitrogen at about λ2300 A.U., and these pass readily through fluorite and crystalline quartz. On the other hand, both fused quartz and mica are opaque to all the rays which excite fluorescence.

The rays give an index of refraction with quartz of 1·75 ± ·08, indicating that they lie in the ultra-Schumann region on the long-wave side of the quartz absorption band. The authors show that the radiation which excites the water band is capable of reflection. C. S. G.

1672. *Fluorescence of Iodine Vapour.* I. **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 829–834, Aug. 30, 1914.)—The author has examined the change produced by temperature in the fluorescence of iodine vapour when the density is maintained constant. It is found that the brightness of the fluorescence is decreased with increasing temperature. By a comparison of his measurements with those of Wood and Speas [Abs. 1075 (1914)] on the relation between the density and the fluorescence, it is concluded that the intensity of fluorescence is not only dependent on the number of collisions of the iodine molecules amongst themselves, or with other electronegative molecules, but also, in general, on the mean distance apart of the molecules. C. S. G.

1673. ***Measurement of the Surface Radiation Energy independent of the Degree of Hardness.*** **T. Christen.** (Phys. Zeits. 16. pp. 362–365, Oct. 1, 1915.)—Shows theoretically that with a specially designed apparatus, which is illustrated by diagrams, the measure of the energy of Röntgen rays per unit area may be obtained correctly although the rays are not homogeneous, the method being independent of the exact degree of hardness of the rays used. E. H. B.

1674. *Observations on the Absorption of Homogeneous X-radiation.* **W. Kossel.** I. and II. (Deutsch. Phys. Gesell., Verh. 16. 20. pp. 898–909, Oct. 30, and pp. 953–963, Nov. 30, 1914.)—*Part I.*—The greater part of this paper is concerned with a general review of the work on this subject by Barkla, Sadler, Moseley, and others. From a consideration of these results it is shown that for a group of adjacent elements—Fe, Ni, Cu, Zn—the mass-absorption coefficient for homogeneous X-radiation bears a simple numerical relation with the atomic number. The behaviour of other elements not in this group, as well as the manner of variation of the absorption coefficient with wave-length, is also discussed.

Part II.—Special consideration is here given to absorption and emission spectra of X-rays of the various elements. Bohr's model of the atom is used as the basis for all the theoretical deductions, whilst the experimental results of Moseley and Moseley and Darwin are used in the comparison between observation and theory. A. B. W.

1675. *Atomic Refraction.* **A. Heydweiller.** (Deutsch. Phys. Gesell., Verh. 16. 14. pp. 722–727, July 30, 1914.)—The refraction produced by a normal solution-in-water of a substance of atomic weight M can be calculated according to the Lorenz-Lorentz relation connecting the percentage difference of density and refractive-index (for long wave-lengths) at different temperatures A_s and A_n, namely, $A_r^\circ = 0{\cdot}2088\,(36{\cdot}80\,A_n^\circ + M - 10\,A_s)$. Values of M, A_s, A_n°, A_r°, p, and A_n/p are tabulated for the majority of the known elements, and subsequently discussed. Plotting the values of atomic refraction and atomic weight, it is shown that a regular periodicity occurs similar to that for the other better-known physical and chemical characteristics of the elements. A. B. W.

1676. *X-ray Photography, showing "Depth."* **P. Knipping.** (Phys. Zeits. 16. pp. 280–282, Aug. 1, 1915.)—X-ray photographs showing clearly the 3-dimensional character of a folded metal gauze have previously been published by B. Alexander [Abs. 1270 (1915)]. This paper contains a set of similar photographs. A. B. W.

1677. *Application of Selenium to the Measurement of X-ray Energies.* **R. Fürstenau.** (Phys. Zeits. 16. pp. 276–279, Aug. 1, 1915.)—Work on this subject by Voltz [see Abs. 1272 (1915)] resulted in the observation that the use of a selenium cell for the comparison and measurement of X-ray energy was unsatisfactory. The author criticises this work, and performs a series of experiments on similar lines. An explanation of the irregular character of Voltz's selenium resistance-curves is given. It appears that Voltz used a type of selenium which is very slow to reach its max. resistance for a particular intensity of the incident X-rays. The author shows that it is possible to produce, by suitable methods, a type of selenium cell which is free from this objection, and which can be used quite satisfactorily in practice for the measurement of the energy of an X-ray beam. **F. Voltz.** (Ibid. pp. 308–311, Aug. 15, 1915.) A. B. W.

1678. *Phenomena observed when X-rays fall on a Straight Edge.* **J. Laub.** (Deutsch. Phys. Gesell., Verh. 17. 16. pp. 354–356, Aug. 30, 1915.)—The paper contains a brief outline of many of the so-called diffraction effects observed when X-rays fall on the edge of a metallic plate, and subsequently on a photographic plate. The influence of the various factors involved, *e.g.* distance of the plate and of the edge of the metal screen from the slit, material of the "diffracting" edge, the material of the antikathode, the shape of the slit, etc., are summarised. If further information is required the original paper must be consulted, as a short comprehensive abstract is impossible. A. B. W.

1679. *Structure of Some Crystals of Spinel Group.* **S. Nishikawa.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 199–209, Sept., 1915.)—The molecular structure of the crystals of spinel group has been found to be a space-lattice having the same symmetry properties as the diamond-lattice. It consists of two hemihedral face-centred lattices interpenetrating each other, the elementary cube being made up of 8 molecules of $R''R_2'''O_4$. The position of the oxygen atoms varies according to the nature of the atoms R'' and R'''. The theory is reconcilable with the results of Bragg's spectrometric measurements, except in the case of the reflection from the (1, 1, 1) plane. The crystals used in the above experiments were spinel ($MgAl_2O_4$) and magnetite ($FeFe_2O_4$). A. B. W.

1680. *Passage of Light through the Slit of a Spectroscope.* **P. Zeeman.** (K. Akad. Amsterdam, Proc. 18. pp. 412–415, Oct. 30, 1915.)—Though the full resolving power of a spectroscope can be reached only with an infinitely narrow slit, a near approach can be made with a very narrow slit. Taking the "normal" width of the slit $d = f\lambda/4D$ (where f and D are respectively the focal length and diam. of the objective), the "purity" of the spectrum is only 1·4 % below its max. value [see Abs. 1196 (1905)]. With a slit of width $2d$ we get about double the quantity of light, while the purity only falls 5·7 % below its max. value. More than 4 times the normal width of the slit must never be taken, for then the purity of the spectrum decreases rapidly, while even for a very wide slit the intensity of the light never exceeds 4 times the value obtainable with normal width. Hence, for sufficiently intense sources of light a width of slit in the neighbourhood of $f\lambda/4D$ is the best. A narrower slit causes loss of light with little gain in resolving power, and a wider one soon decreases the resolving power considerably. The author has previously pointed out that by using very narrow slits the observation of the polarised components of magnetically resolved lines may be rendered very difficult. As the slit is made narrower the electric vibrations perpendicular to the slit are transmitted less and less. The present paper gives details of some measurements concerning the width of slit necessary for the appearance of these polarisation phenomena. Monochromatic light was allowed to fall on a slit behind which a calcite rhomb was placed at such a distance that two adjacent images of the slit were formed, one containing the vertical, the other the horizontal vibrations. By means of a Nicol prism the intensity of the two images may be made equal. If OP and OQ are the directions of the vibrations in the two images and that for the nicol is perpendicular to PQ, the condition for equal intensities of the two images will be $\tan \alpha = OP/OQ$, where α is the angle OQP. The ratio of the intensities of the horizontal and vertical vibrations is then given by $\tan^2 \alpha$. Using two platinoid slits the following values were obtained for $\tan \alpha$ with various slit-widths (w) :—

First Slit.		Second Slit.			
Green Light.		Red Light.		Green Light.	
w (mm.).	Tan α.	w.	Tan α.	w.	Tan α.
0·010	1·0	0·0017	1	0·0015	1
0·004	0·5	0·0015	0·7	0·0013	0·6
0·002	0·3	0·0013	0·5	0·0010	0·5
0·001	0·2	0·0010	0·3	0·0007	0·3
		0·0005	0	0·0004	0

The difference in absolute width at which the same phenomena occur for the two slits is interesting. Probably the form of the edges of the slit is of much importance here. The variation with wave-length has the direction we should expect. It appears from these results that with slit widths often used the polarisation phenomena are of some importance. A. W.

1681. *Symmetry of Röntgen-patterns of Trigonal and Hexagonal Crystals.* **H. Haga** and **F. M. Jaeger.** (K. Akad. Amsterdam, Proc. 18. pp. 542–558, Oct. 30, 1915.)—An interesting paper containing a large number of plates and stereographical projections of "Röntgenograms" which illustrate the text. An illustrated discussion is also given of the normal and abnormal diffraction-images of birefringent crystals in general.

The original paper should be consulted as no short abstract is possible. A. B. W.

1682. *Symmetry of Röntgen-patterns of Rhombic Crystals.* **H. Haga** and **F. M. Jaeger.** (K. Akad. Amsterdam, Proc. 18. pp. 559–571, Oct. 30, 1915.) —This paper contains a record of the results obtained in investigations with rhombic crystals, especially with representatives from each of the possible symmetry classes of the rhombic system.

Reproductions, with their stereographical projections, of the original photographs are given in illustration. For details the original paper should be consulted. A. B. W.

1683. *Secondary Rays from Canal Rays in Gases and Vapours.* **H. Baerwald.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 789–798, Aug. 30, 1914.)—

It has been previously found that the quantity of secondary radiation exhibits no dependence on the nature of the substance subjected to the action of the canal rays. N. R. Campbell obtained similar results with his experiments on the δ-rays. The recent experiments deal with the following points: Current-tension curves; Ionisation and energy curves; Connection of the secondary radiation with the emission of light. The chief results obtained are thus summarised:—The quantity of secondary radiation generated by canal rays in gases and vapours is proportional to the energy of the primary rays. The quantity of secondary radiation set free by a canal ray in different gases points to a specific action depending on the nature of the particles. The light emission of canal rays shows the same behaviour as the secondary rays evoked by such emission; their energy is likewise proportional and they exhibit the same specific differences in different atmospheres as the latter. [See also Abs. 1470 (1913), 527 (1914).] A. E. G.

1684. *Relation between the Life of Radio-active Substances and the Range of the Rays Emitted.* **F. A. Lindemann.** (Phil. Mag. 30. pp. 560–563, Oct., 1915.)—Using the assumptions (1) that the nucleus of a radio-active atom becomes unstable when N independent particles of this nucleus all pass through some unknown critical position within a short time, and (2) that this short time τ is of the order of the time taken by a strain to traverse the nucleus, the author develops the well-known formulæ connecting the life and range of the radio-active elements. It follows that the explosion of an atom necessitates the fortuitous coincidence of some 30 independent events. A calculation of the radius of the nuclei of radio-active atoms on the above assumptions leads to a value of the order $3{\cdot}9 \times 10^{-13}$ cm. If λ is the decay constant and R the range of the particle emitted from a radio-active element, it is shown that

(1) $\log_{10}\lambda = -36{\cdot}9 + 53{\cdot}3\log_{10}R$—for the uranium-radium family;
(2) $\log_{10}\lambda = -38{\cdot}4 + 53{\cdot}3\log_{10}R$—for the thorium series; and
(3) $\log_{10}\lambda = -39{\cdot}6 + 53{\cdot}3\log_{10}R$—for the actinium series.

Comparing these relations it will be seen that the constant A in Geiger and Nuttall's formula $\log\lambda = A + B\log R$, has different values in the different radio-active series. A physical explanation of this difference is suggested. A. B. W.

1685. *Comparison of Radium Standard Solutions.* **J. Moran.** (Phil. Mag. 30. pp. 660–664, Oct., 1915.)—The object of this work was to determine the accurate value of the Rutherford-Boltwood standard radium solution at McGill University, by comparison with the Washington Standard Solution. The former was compared initially with the Rutherford-Boltwood *solid* standard, which is known to be 4·9 % too low on the International [see Abs. 184 (1915)]. If no errors were made in their preparation, we should expect the solution standards to come out similarly. This work shows fair agreement—about 3 % low, whereas the solid standard is 4·9 % low. The strong and weak solutions of the Rutherford-Boltwood standard, prepared in the ratio 100:1, turn out to be in good agreement. This shows that no serious deterioration has occurred with time.

It has been found that a radium bromide solution deteriorates with each boiling. Also that if a sufficient amount of hydrochloric acid, free from radio-active matter, is added, the solution will recover its normal emanating power. The cause of this has not yet been ascertained. A. B. W.

1686. *Velocities of the α-Particles from Thorium Active Deposit.* **A. B. Wood.** (Phil. Mag. 30. pp. 702–710, Nov., 1915.)—By measuring their relative deflections in a magnetic field, an accurate comparison has been made, by the photographic method, between the velocities of the two groups of α-particles (ranges 4·8 cm. and 8·6 cm.) expelled from thorium active deposit. The mean value of the ratio of these velocities is found to be 1 : 0·882, whereas the value calculated from Geiger's relation ($v^3 = kR$) is 1 : 0·826. To explain this difference it is suggested that the value 4·8 cm., previously accepted as the range of α-particles from ThC, should be increased to 4·95 cm. A direct comparison has been made between the velocities of the α-particles expelled from Th active deposit and those expelled from RaC. Taking the velocity of the α-particles of 8·6 cm. range (from ThC_2) as unity, we have—

α-Particle.		Observed Velocity.	Velocity calculated from Geiger's Relation ($v^3 = kR$).
Source.	Range.		
ThC_2	8·6 cm.	1	1
RaC	6·94 cm.	0·932	0·932
ThC_1	4·8 cm.	0·882	0·826

Using the standard value $1{\cdot}922 \times 10^9$ cm./sec. as the velocity of the α-particles from radium C, it is found that (*a*) Velocity of α-particles from $ThC_2 = 2{\cdot}060 \times 10^9$ cm./sec ; (*b*) Velocity of α-particles from $ThC_1 = 1{\cdot}714 \times 10^9$ cm./sec. The relative intensities of the two α-ray lines shown in the photographs are discussed with regard to the question of the relative numbers of α-particles expelled with ranges of 8·6 cm. and 4·8 cm. respectively. No evidence has been obtained as indicating a difference of mass of the two sets of α-particles. A. W.

1687. *Ionisation Track of α-Rays in Hydrogen.* **J. C. MacLennan** and **H. V. Mercer.** (Phil. Mag. 30. pp. 676–683, Nov., 1915. Paper read before the Roy. Soc. of Canada, May, 1915.)—To throw light on the question as to whether "H" particles (produced when α-rays pass through hydrogen) are capable of ionising a gas, an experimental study has been made of ionisation tracks of α-rays in hydrogen. The method followed was precisely the same as that of C. T. R. Wilson [Abs. 1885 (1912)]. The photographs shown in the paper confirm the observation of Wilson, and support the contention of Rutherford that apart from the crooks at the ends of the α-ray tracks, the scattering is due to single deflections through considerable angles. The experiments fail to bring out evidence in support of ionisation by the nuclei of hydrogen atoms projected from the latter when α-particles collide with the atoms. The observations go to show that when α-particles are projected through hydrogen, or through hydrogen containing traces of air, exceedingly few collisions occur which result in the ejection of a hydrogen nucleus.

A. B. W.

1688. *Photographic Registration of α- and β-Particles.* **J. E. Shrader.** (Phys. Rev. 6. pp. 292–302, Oct., 1915.)—In this paper experiments are described by which it has been attempted to eliminate as far as possible the "natural disturbances" encountered by Rutherford and Geiger [see Abs. 246 (1913)] in their experiments on the counting of α-particles. The authors consider that by the use of a Pt-point, which can be thoroughly heated without destroying the point, the natural disturbances can all be eliminated. The seat of these natural disturbances is in the point, and their number is not affected by the size of the ionisation chamber. A description is given of a series of experiments with points of varying degrees of sharpness, and with different gases in the discharge tube. Air, hydrygen, oxygen, and CO_2 can be used equally well, the only difference being one of the value of the potential necessary to produce the ray discharge.

The apparatus adopted finally has been used to determine the rate of decay of ThB, and the agreement with the accepted value is good.

A. B. W.

1689. *Decrease in Velocity of β-Particles in passing through Matter.* **W. F. Rawlinson.** (Phil. Mag. 30. pp. 627–632, Oct., 1915.)—The decrease in velocity of β-particles in traversing matter is difficult to measure on account of the marked scattering which they undergo. W. Wilson [Abs. 1488 (1910)] examined the question by an ionisation method, but as his initial beam was not homogeneous, his final results prove only that there is a reduction in the average velocity of β-rays in passing through matter. O. v. Baeyer [Abs. 1708 (1912)] also attacked the problem by a photographic method and obtained results similar to those of Wilson. Quantitative measurements, by a photographic method, were first obtained by Danysz [Abs. 1349 (1911)]. Bohr [Abs. 1720 (1915)] has developed a theory of the decrease of velocity of electrified particles in passing through matter. He concludes that $I\beta^3$ should be approximately constant for any given substance (I being the decrease in velocity in passing through a screen whose weight per unit area is 0·01 gm., and β the ratio of the velocity of β-ray to the velocity of light). According to Bohr this product should be less for elements of high atomic weight than for the lighter elements; also for any given substance it should increase slightly with velocity of the β-rays. Using the apparatus employed by Rutherford and Robinson [Abs. 251 (1914)] for the analysis of β-rays, the author investigates experimentally the principal points of Bohr's theory. The results, though incomplete, certainly seem to support the theory; the values of $I\beta^3$ for *tin* being consistently slightly lower than those for mica, whilst the values for any one substance are approximately constant, but increase somewhat for high-velocity β-rays. A fine thin-walled tube (an α-ray tube) containing Ra-emanation was employed as the source of β-rays in these experiments.

A. B. W.

1690. *β-Radiation from Ra-D and the Absorption Law for β-Rays.* **L. Meitner.** (Phys. Zeits. 16. pp. 272–276, Aug. 1, 1915.)—Measurements have been made on the β-radiation from RaD by electroscopic methods, and a determination of the absorption of this radiation in Al has been undertaken. It is shown that the ordinary electroscopic methods can, under suitable conditions, be applied in studying the absorption of extremely soft β-radiation; the range of velocity being 0·33 to 0·39 that of light. For the absorption coefficient of the radiation from RaD (extremely soft) in Al the approximate value of 5500 $cm.^{-1}$ is given.

From a series of observations on the absorption of β-rays, of different velocities, in matter, it appears that the reduction of the velocity of a β-particle to zero is not brought about by a large number of successive collisions of the particle with the "absorbing" molecules. It is suggested that the β-particle probably penetrates into the interior of an atom of the absorbing layer and is then held fast by the internal forces which are there known to exist, *i.e.* the β-particles lose their energy by a single collision. A. B. W.

1691. *Penetrating Radiation at High Altitudes.* **W. Kolhörster.** (Deutsch. Phys. Gesell., Verh. 16. 14. pp. 719–721, July 30, 1914.)—A series of experiments on the determination of the penetrating radiation present in the earth's atmosphere have been made at various known altitudes above the earth's surface. The instrument used in measuring the ionisation was the author's modification [see Abs. 888 (1914)] of the Wulf type of electrometer. The following interesting table of results is given :—

Height above Sea-level (Metres).	Difference between the Number of Ions per cub. m. at the Height considered and on the Earth's Surface.	
	Values obtained in 1913.	Values obtained in 1914.
1000	− 1·5	—
2000	+ 1·2	—
3000	+ 4·0	+ 4·3
4000	+ 8·3	+ 9·3
5000	+16·5	+17·2
6000	+28·7	+28·7
7000	—	+44·2
8000	—	+61·3
9000	—	+80·4

Assuming the relation $I = I_0 e^{-\lambda d}$ for this radiation, the value of the absorption coefficient λ for air at atmospheric pressure is given as 1×10^{-5} cm.$^{-1}$, whereas that of the γ-radiation from RaC is $4{\cdot}5 \times 10^{-5}$ cm.$^{-1}$. This radiation is therefore extremely hard, being only reduced in intensity by 1 % in a layer of air (at atmospheric pressure) 7 km. in thickness. It is shown in the above manner that a very penetrating radiation exists which has its origin somewhere in space, but by far the greater part is due to the sun. A. B. W.

1692. *Delta-radiation emitted by Zinc when Bombarded by Alpha-rays.* **J. C. McLennan** and **C. G. Pound.** (Phil. Mag. 30. pp. 491–502, Oct., 1915. Paper read before the Roy. Soc. of Canada, May, 1915.)—In some experiments by Pound [Abs. 1845 (1912)] it was shown that the δ-radiation emitted from carbon when bombarded by the α-rays from polonium increased very considerably when the temperature of the carbon was lowered to the temperature of liquid air. He showed that this increase in the δ-radiation was due to an increase in the amount of air occluded in the surface of the carbon.

In the present investigation it has been shown that when a plate of zinc with a freshly scraped surface is placed in a highly-exhausted chamber and bombarded by α-rays there is an emission of slow-moving electrons, or δ-rays, from it at the rate of 3 electrons for each α-particle impact. It is found that the emission of electrons from such a plate of zinc under bombardment by α-rays diminishes with the lapse of time from the moment when it was placed in the high vacuum; that initially there is no emission of electrons under bombardment by α-rays from a surface of zinc deposited from Zn-vapour in a high vacuum; but that as time elapses an electronic emission is gradually developed under the gradual absorption of air by the surface of the Zn-deposit. A. B. W.

1693. *The Penetrating Radiation present in the Atmosphere.* **A. Gockel.** (Phys. Zeits. 16. pp. 345–352, Oct. 1, 1915.)—The author briefly reviews the results obtained by other workers up to the present time, in various localities, under water, above water and ground, and at considerable heights in the atmosphere. The question of instrumental errors is taken up; the effects of changes of temperature and of humidity, and of variations in barometric pressure are also considered. The author also avails himself of existing data, and of those obtained from his own researches, in the endeavour to ascertain whether or not there are regular daily and also seasonal variations in the penetrating radiation. Experiments have been carried out by the author, with the aid of Wulf's "Strahler," as well as with an arrangement devised by himself, using Benndorf's electrometer (registration instrument). Measurements have been carried out at the Bodensee by balloons, above the ice of the Eiger and the Grindelwald glaciers; on the Aletsch glacier, on the Eggishorn, on the snow of the Jungfrau ridge, in ice grottoes, as well as near the bare rocks; also in the propinquity of grass-land and gardens in Freiburg in Switzerland, together with other places. A few of the results can only be given here. The figures denote the production of ions per cm.^{3} per sec. At the Bodensee, Nov. 12, 1913: at 1 m. above water, 13·3; at 2 m. under water, 12·7; at 4 m., 11·6; and at 6 m., 10·6. In a garden in Freiburg, above the turf, 11·3 (dates not given); on the Aletsch glacier, at 2300 m., 10·7; near the gneiss rocks of the Trugberg, 19·6; and by the mica schist on the Eggishorn, 2200 m., 16·8. The strongest radiation observed by the author was that in the Lötschberg tunnel, through the granite, where measurement gave 30 ions per cm.^{3} per sec.

From his investigations the author draws the following deductions:—(1) A depth of water of 3·5 m. is insufficient to absorb the radiation (cosmic?) coming from the atmosphere. (2) The observations on glaciers, as also with balloon ascents, show that there is an increase of the penetrating radiation with the height. (3) From solid crystalline rocks radiation is more intense than from cultivated alluvial sail. (4) A daily oscillation of the penetrating radiation is not noticeable in Freiburg. (5) That portion of the radiation which comes from the earth is stronger in the warm season than in the cold. (6) The radiation coming from the atmosphere at a height over 2200 m. shows an oscillation from day to day. Further observations on mountain-tops are desirable in this connection.

It has been supposed owing to the fact that at low elevations the production of ions is small, while at great height the production is so large, that the sun is the direct source of the radiation. Against this theory is the lack of variation between day and night. It would be of interest to see how the radiation is affected during sun-spot periods, and whether it is measurably influenced by the declination of the sun. On the Atlantic Ocean, at a distance from the land a sensible local and temporary oscillation has been noticed to accord with that of the barometer. Lower pressure seems to favour an increase in the radiation. Again, upon approaching the land, a stronger radiation has been observed, and there appears to be an oscillation corresponding daily with the periods during which the land and sea breezes prevail. These facts militate against the view that the sun is the immediate source of the penetrating radiation. E. O. W.

HEAT.

1694. *Thermal and Electrical Conductivities of Metals.* **W. Meissner.** (Ann. d. Physik, 47. 8. pp. 1001–1058, Sept. 14, 1915. Communication from the Physical.-Techn. Reichsanstalt.)—The author has investigated the relation between the thermal conductivity λ and the electrical conductity σ for the metals Cu, Pt, and Pb over the temperature range 20° to 878° abs. The method used was Diesselhorst's modification of the well-known Kohlrausch method. The author found that $\lambda/\sigma T$ and $1/\lambda$ decreased about 85 % when the temperature was lowered from 278° to 20° abs. The temperature dependence of $\lambda/\sigma T$ and $1/\lambda$ is similar to that of the atomic heat ($T=$ abs. temp.). The method of working, the results obtained by previous observers, and the bearing of the results on the electron theory are very fully discussed. [See Abs. 1082 (1914).] I. W.

1695. *A Method of measuring Heat Conductivities.* **R. W. King.** (Phys. Rev. 6. pp. 77–78, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—The thermal conductivity of metals in the form of wires 2·5 mm. in diam. and 25 to 40 cm. in length (copper and iron only have so far been dealt with) is determined by a modification of Ångström's periodic method. One end of the wire is inserted in a small heating coil through which flows a periodic current whose value is given by the expression $I = I_0 \sin \tfrac{1}{2} \omega t$. The velocity of propagation of the temperature wave is obtained by noting the time lag between the motions of two short-period galvanometers connected with thermo-couples attached a few cm. apart to the heated end of the wire. Under these conditions the solution of the differential equation expressing the linear flow of heat is shown to be $\theta = \theta_1 e^{-p_1 x} + \theta_2 e^{-p_2 x} \cos(\omega t - qx)$, where $q = (k/2)^{\frac{1}{2}}[-\mu + (\mu^2 + \omega^2)^{\frac{1}{2}}]^{\frac{1}{2}}$, μ being the radiation constant, and k the thermal conductivity divided by the product of density and specific heat. Experiments are done in pairs, and by determining the velocities corresponding to $\omega_1 \omega_2$ in a rod for which μ remains constant, it is possible to eliminate this quantity and determine k. Sample results are given :—

Copper.			Tin.		
Period in Secs.	Time Lag. in Secs.	Conductivity in Abs. Units.	Period in Secs.	Time Lag. in Secs.	Conductivity in Abs. Units.
129·3	12·12	0·907	129·7	11·30	0·1551
291·3	16·60		290·0	14·86	

By enclosing the test-piece and heating coil in an electric furnace the conductivity of copper at 860° C. is found to be 0·858. The experiments are to be extended to high and low temperatures and an attempt is to be made to apply the method also to poor conductors. T. B.

1696. *Diathermancy of Liquids—Correction for Containing Vessel.* **J. Vallot.** (Comptes Rendus, 161. pp. 127–129, Aug. 9, 1915.)—In order to eliminate the effects of the end plates of the containing vessel it is usual to calculate the diathermancy of a liquid from the ratio of the intensity of the radiation after passing through the vessel filled with liquid to the intensity after traversing the empty vessel. This is incorrect because the end-plates, in addition to absorbing some of the radiation, also reflect it, and the reflection from the inside surfaces is altered when the plates are in contact with the liquid. To allow for this the author takes as the denominator of the ratio the intensity of the radiation passing through the two end-plates squeezed together with just a capillary layer of the liquid in between. The older method of calculation gives, for many liquids, a diathermancy greater than 100 %, especially when only small thicknesses are dealt with (*e.g.* 0·2 mm.). The new method removes this anomaly. D. O. W.

1697. *Hypothesis concerning the Specific Heat and the Plasticity of Metals.* **F. Skaupy.** (Deutsch. Phys. Gesell., Verh. 17. 15. pp. 269–270, Aug. 15, 1915.)—From measurements of the specific heats of metals at different temperatures Nernst has concluded that either (1) free electrons are present in the metals only in small quantities ; or (2) for these electrons the gas laws do not hold. The author, rejecting the first hypothesis, develops a view which is a special form of the second possibility. He advances the idea that in a metal, by the dissociation of an atom, not only the electron, but also the "atom ion" connected with the atom, pass out of the space-lattice. Both types are then in a free condition, and possess a mean kinetic energy which is equal to the mean kinetic energy of the non-electric atom remaining in the "lattice." This assumption of a free "atom ion" makes the plasticity of metals appear in another light. The presence of a large number of free molecules, which now pass out of the space-lattice, and now enter it again, must increase the number of the "slipping planes" which determine the plasticity. The degree of dissociation of a metal is thus very closely connected with its plasticity. For alkaline metals, the electro-positive nature of which leads us to expect the most complete dissociation, this connection appears to be most obvious. T. B.

1698. *Maximal Velocity of Evaporation of Mercury.* **M. Knudsen.** (Ann. d. Physik, 47. 5. pp. 697–708, Aug. 5, 1915.)—The author first obtains a formula for the velocity of evaporation, assuming that the molecules which leave the surface of the liquid do not return again to it. The formula is $G = 43{\cdot}75 \times 10^{-6}\sqrt{(Mp/\theta)}$, where M is the molecular weight, θ the temperature, and p the vapour pressure in dynes/cm.^{2}. The calculated value for mercury is 7·81 mgm., the observed value is 7·48 mgm. A. F.

1699. *Determination of the True Temperature of a Solid Body from the Intersection Point of the "Logarithmic Isochromates" in the Visible Spectrum.* **E[lisabeth] Benedict.** (Ann. d. Physik, 47. 5. pp. 641–678, Aug. 5, 1915. Dissertation, Breslau.)—The distribution of energy in the spectrum of a black body is given sufficiently accurately by Wien's form of Planck's equation, $E_\lambda = c_1\lambda^{-5} . e^{-c_2/\lambda T}$. Hence $\log E_\lambda = \log(c_1\lambda^{-5}) - c_2/\lambda T$, that is $\log E_\lambda$ is a linear function of 1/T. This has been verified by Lummer and Pringsheim, who, on comparing the brightness of a black body at different temperatures and wave-lengths with that of a constant source (a carbon filament lamp), showed that the black Logarithmic Isochromates (Log. Isos.), or curves connecting $\log E_\lambda$ and 1/T, are straight lines. They also discovered the remarkable law that the Log. Isos. of a black body met in a single point.

This seems to imply that at a definite temperature of the black body, the source with which it is being compared has the same energy distribution as the black body; *i.e.* it radiates as a "grey" body. At the same time it would appear that the temperature given by the cutting point of the Log. Isos. is the true temperature of the *comparison source* used. This furnishes therefore a new method of temperature determination (for grey or black bodies). The author has carried out experiments on these lines with the following results:—(1) The intersection of grey or black Log. Isos. has proved a sensitive criterion of the power of absorption of the radiating body. (2) We can substitute a carbon filament lamp for a black body in the measurement of radiation in the visible spectrum, for it radiates like a grey body in the temperature interval 1500°–4200° (abs.), as shown by the fact that its Log. Isos. are straight lines meeting in one point. (3) The intersection point of the grey Log. Isos. gives for grey bodies an exact measurement of the true temperature. For the arc light this temperature is 4200° abs. with max. error of 1 %. (4) The absence of a cutting point of the grey Log. Isos. in the case of platinum, Osram, and Osmium lamps, and of the incandescent gas-burner, shows that these radiate selectively. (5) The distribution of energy in the visible part of the spectrum for the radiation of Pt is given by the equation $E_\lambda = C\lambda^{-0 \cdot 8} . e^{-c_2/\lambda T}$. (6) The experiments on Nernst's filaments show that their emission at low temperatures is selective, but approaches at high temperatures the emission of a grey, and finally a black, radiation.

T. B.

1700. *Theory of Fusion.* **S. Ratnowsky.** (Deutsch. Phys. Gesell., Verh. 16. 24. pp. 1033–1042, Dec. 30, 1914.)—This is the first of a series of papers containing an attempt to extend the quantum theory to liquids. Assuming that the motion of liquid molecules, like that of solids, consists of vibrations about fixed centres (which may be mutually interchanged), it is shown that the entropy per gm.-atom is, in each case, a function of the ratio ν_m/T (ν_m = max. frequency) or θ/T, where θ is a characteristic temperature equal to $h\nu_m/k$; k being the Boltzmann constant [Abs. 1014 (1913)]. When θ is small compared with T, as it is at the melting-point, a simple approximate expression can be deduced for the entropy, and this, combined with the ordinary thermodynamic connection between the latent heat of fusion and the entropies of the solid and liquid phases at the melting-point, gives an equation connecting the latent heat and the characteristic temperatures of the solid (θ) and the liquid (θ'). No method of calculating θ' is available, so that the equation cannot be tested numerically. It can be used to calculate θ/θ', and for elementary substances this ratio is found to be fairly constant and equal to 1·35. For compounds consisting of 2, 3, or 4 atoms the ratio is again constant and equal to 1·65. These cases, however, require further assumptions as to the number of degrees of freedom possessed by a molecule.

It is shown that, to give the requisite value of θ/θ', the ice molecule must be $2H_2O$, and that of silver bromide 2AgBr. Other interesting cases are discussed.

D. O. W.

1701. *Electron Theory of Metals and Nernst's Formula.* **K. F. Herzfeld.** (Phys. Zeits. 16. pp. 354–362, Oct. 1, 1915.)—A mathematical discussion based upon specified assumptions, the chief of which are as follows:—(1) In solid metals and their vapours, only the valency electrons are easily split off; they appear in the solid metals as the free conductivity electrons, and for them the classical gas laws are valid. (2) For the distribution of the ions between water and vapour the classical gas laws hold, *i.e.* Boltzmann's *e*-Theorem. (3) The Sackur-Stern-Tetrode vapour-pressure formula holds. (4) The splitting-off of the two valency electrons occurs in a specified sequence. E. H. B.

1702. *Internal Pressure of Gases: Influence of Pressure.* **A. Leduc.** (Comptes Rendus, 161. pp. 97–100, Aug. 2, 1915.)—The author has extended his theoretical investigation of the behaviour of SO_2 [see Abs. 1869 (1911)] to 1000°, and has arrived in this way at an exceedingly simple law for the phenomena concerned. The internal pressure diminishes rapidly at first, then more slowly, and if the curve $w = f(\chi)$ be plotted it can be seen that as χ, the reciprocal of the reduced temperature tends towards zero (*i.e.* when T increases indefinitely), w tends towards a finite limit, and not towards zero as the formulæ of Clausius and of Sarrau would indicate. L. H. W.

1703. *Reflections on the Kinetic Theory.* III. *Actual Gases and van der Waals' Equation.* **E. Bouty.** (Journ. de Physique, 4. pp. 601–621, Aug.–Sept., 1914.)—In earlier instalments the author dealt only with perfect gases [Abs. 911 (1914), 710 (1915)]. L. H. W.

1704. *An Equation of State for Normal Substances Tested in the Vapour Dome.* **H. N. Davis.** (Phys. Rev. 6. pp. 59–61, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—The equation discussed is—

$$(p + a\phi(\theta)\, v^{m}\, (v - b) = \mathrm{RT},$$

the reduced form of which is—

$$(\pi + \phi(\theta)/\omega_0\omega^{m})\,(\omega - \omega_0) = \Delta_c\theta,$$

where $\omega_0 = (m-1)/(m+1)$ and $\Delta_c = 4m/(m^2-1)$ are respectively the limiting reduced orthobaric volume and the ratio of the critical density to the density of a perfect gas at the critical pressure and temperature. The equation has been tested for argon and for 11 other substances. These 12 substances and some 15 others are shown to satisfy this relation, at least approximately, and probably within the limit of error of the observed values of ω_0. It is therefore possible to select a value for m for each substance which will give substantially correct values for both ω_0 and Δ_c. The applications of the equation to the determination of the vapour-pressure curve and to the determination of critical volumes is also discussed. The accuracy with which latent heats can be predicted is very great. Finally, the paper puts in an easily tested form the hypothesis that the law of corresponding states, which is untrue in its original form, is true if we give it a single degree of freedom by introducing one disposable constant. In this paper the additional constant is the exponent m in the reduced equation of state, and it is found that at least for ω_0, Δ_c, vapour pressures and values of the ratio $\omega_{\mathrm{liq.}}/\omega_{\mathrm{vap.}}$, a one-dimensional law of corresponding states is in substantial agreement with the facts. Indeed, the validity of such a law is apparently greater than the validity of the particular form of equation of state that has been discussed. A. F.

1705. *Entropy in Condensed (Solid and Liquid) Substances and its Variations with Change of State.* **S. Pagliani.** (N. Cimento, 10. pp. 5–88, July–Aug., 1915.)—The author has calculated, by means of the expression given by Planck, $S = \int_0^T c_p/T \, . \, dT$, the values of the absolute entropy at the melting-point for those simple and compound substances for which experimental data on specific heats are available. The numbers thus obtained show that, for the elements, the value of the entropy at the melting-point tends to diminish as the atomic weight increases. This relation holds exactly for the members of the separate groups of the periodic system, when the metals are classified apart from the non-metals. But, even in any separate group, the products of entropy and atomic weight are not constant. Tammann's assertion that the entropy per gm.-atom in the metals before fusion is independent of the metal is, therefore, inaccurate. This result is discussed in relation to modern atomistic doctrines.

For the frequency of the atomic vibratory motion, Lindemann gives the expression $\nu = k\sqrt{(T/mV^{2/3})}$,, where k is a coefficient determined empirically, T the absolute melting-point, m the atomic mass, and V the atomic volume. From this it follows that the values of the frequency should diminish with increase of the atomic weight. The author has calculated the values of ν for the elements and finds that the metals may be divided into three classes, according to the value of the ratio of the entropy to the atomic vibratory frequency: (I) The alkali metals, for which S/ν has the mean value 0·36; (II) the metals of the second, third, fourth, and sixth groups, and the first series of the eighth group of the periodic system, for which S/ν has the mean value 0·146; (III) those of the fifth group and of the second series of the eighth group, for which S/ν has the mean value 0·10. (IV) The non-metals form a separate class, the mean value of S/ν being 0·22. Consequently, the frequency of the atom in different substances may be calculated by multiplying the entropy by a factor of proportionality, this being obtained by dividing the coefficient of Lindemann's formula by the corresponding mean value of S/ν. To this coefficient different values have been ascribed, the one most generally adopted being $2{\cdot}12 \times 10^{12}$; this would give, for the proportionality factors corresponding with the above four classes of elements, the respective values 6·0, 14·5, 21·2, and $9{\cdot}6 \times 10^{12}$.

Not only the values of the entropy of the elements in the three states of aggregation, but also the variations of these values with change of state, tend to diminish with increase of the atomic coefficients, that is, with diminution of the number of atoms in the unit mass. This law holds generally for the metals and non-metals, taken separately, but the fact that it is obeyed rigorously only by the elements constituting any one group of the periodic system leads to the conclusion that the entropy is influenced also by the chemical character of the element. Thus, with equal atomic coefficients, the magnitude of the entropy is greater for the alkali metals than for the others, and relatively less for the non-metals than for the metals. T. H. P.

1706. *Methods and Apparatus used in the Cryogenic Laboratory. XVI. The Neon-cycle.* **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 18. pp. 507–515, Oct. 30, 1915. Comm. No. 147*c* from the Phys. Lab., Leiden.)—It has hitherto been impossible to obtain baths of constant temperatures between 55° and 20° K. The use of hydrogen gives the range 14–20° K. and the similar use of neon extends this to 27° K. Further, no serious difficulty is encountered in the construction of cryostats for pressures some atmospheres above the normal, and a pressure-cryostat with neon will probably admit of the temperature 34° K., and hence render possible an eye-study of the critical phenomena of hydrogen in a bath of liquid neon. As regards the region 34–55° K., constant temperatures may be obtained by means of hydrogen vapour heated to the desired temperatures; an arrangement for effecting this is to be described shortly. In the present paper the neon liquefactor and cryostat are described. T. H. P.

1707. *Specific Heat at Low Temperatures.* II. *Measurements on the Specific Heat of Copper between* 14° *and* 90° *K.* **W. H. Keesom** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 18. pp. 484–498, Oct. 30, 1915. Comm. No. 147*a* from the Phys. Lab., Leiden.)—The authors have improved the experimental arrangement previously employed [see Abs. 467 (1915)], especially as regards the measurement of resistance for determining the rise of temperature in the calorimeter. The copper tested was the block used in the previous measurements. The values obtained for the atomic heat between 14° and 90° K. are in good agreement with those calculated from Debye's formula with $\theta = 315$ [see Abs. 446 (1913)]; in this region the ratio of the largest to the smallest value of the measured atomic heat is more than 80. Comparison of the atomic heats of copper in the region of the liquid-hydrogen temperatures with Debye's T^3 law for low temperatures, $C_v = 464{\cdot}1(T/\theta)^3$, shows that with fall of temperature the atomic heat decreases more rapidly than follows from this law. In the liquid-hydrogen region and above it, up to 40° K., the value of θ decreases continuously, this behaviour differing from that of lead, with which θ increases with rise of temperature in the liquid-hydrogen region and begins to decrease at about 80° K. Indications are also obtained of an increase of θ for copper above 70° K., and although such increase scarcely exceeds the limits of accuracy attained in the measurements, it is confirmed by the results of other investigators.

The purity of the copper and that of the lead used in the earlier experiments (*loc. cit.*) were controlled by rolling and annealing rectangular strips of the metals and measuring their resistances at room temperature and in liquid hydrogen. With copper, rolling diminishes considerably the decrease in the resistance between room temperature and the boiling-point of hydrogen. By subsequent annealing not only is the influence of rolling on the copper annulled, but the decrease of the resistance between the temperatures just mentioned becomes greater than that of the copper before rolling and annealing. Further, annealing appears to annul the influence of the previous filing, probably in consequence of the fact that the metal has united again to larger crystals. The temperature-coefficient at liquid-hydrogen temperatures undergoes only a small change as a result of the above manipulations. The variation in the resistance of lead is changed either not at all or but slightly by rolling. T. H. P.

1708. *Isothermals of Diatomic Substances and their Binary Mixtures.* XVII. *Preliminary Measurements concerning the Isothermal of Hydrogen at* 20° *C. from* 60 *to* 90 *Atmospheres' Pressure.* **H. K. Onnes, C. Dorsman,** and **G. Holst.** (K. Akad. Amsterdam, Proc. 18. pp. 458–464, Oct. 30, 1915. Comm. No. 146*a* from the Phys. Lab., Leiden.)—Preliminary investigation of the isothermal of hydrogen at 20° C. and 60–90 atmos. shows that extrapolation beyond 60 atmos. by means of Schalkwijk's formula [Abs. 2000 (1914)], although of diminished accuracy, is still sufficiently accurate to support the suggestion that Amagat's value for 100 atmos. is too high. The error appears, however, to be less than 1 : 500, which is the amount deduced from Schalkwijk's formula. T. H. P.

1709. *Isothermals of Diatomic Substances and their Binary Mixtures.* XVIII. *Isothermal of Hydrogen at* 20° *C. from* 60 *to* 100 *Atmos.* **H. K. Onnes, C. A.**

Crommelin, and **E. I. Smid.** (K. Akad. Amsterdam, Proc. 18. pp. 465–472, Oct. 30, 1915. Comm. No. 146*b* from the Phys. Lab., Leiden.)—The measurements here described form the first part of a more accurate investigation to obtain a bridge between the accurate hydrogen isothermal for 20° C. traced by Schalkwijk (1901) between 4 and 60 atmos. and Amagat's isothermal (1893), which begins only at 100 atmos. (see preceding Abs.). The deviations of the results obtained from those calculated by means of Schalkwijk's formula [Abs. 2000 (1914)] are small near 60 atmos., but at higher pressures they become much larger and greatly exceed the limits of accuracy of the measurements. From the value found by Onnes and Braak for the first virial coefficient at 0°, namely 0·99942, this coefficient is calculated to be 1·07261 at 20°. The values of the second and third virial coefficients, B_A and C_A, are calculated by the method of least squares from all the observations made by Schalkwijk and the authors between 4 and 100 atmos. In this way the formula for the isothermal of hydrogen at 20° and at 4–100 atmos. becomes: $pv_A = 1{\cdot}07261 + 0{\cdot}65712 \times 10^{-3} . d_A + 1{\cdot}2926 \times 10^{-6} . d_A^2$. The results obtained dispose of the supposition that Amagat's value for pv_A at 0° and 100 atmos. is too high by 1 in 500. The value of C_A in the above equation is about twice as high as would be expected from the values obtained by Onnes and Braak and by Amagat for this coefficient, but no explanation is evident for this divergence. T. H. P.

1710. *Quantum Theory.* **A. Einstein.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 820–828, Aug. 30, 1914.)—Remarks upon Planck's classical theory pointing out the exact conditions under which alone some of the assumptions are valid. E. H. B.

1711. *Law of Velocity Distribution.* II. **E. Gehrcke.** (Deutsch. Phys. Gesell., Verh. 16. 20. pp. 910–912, Oct. 30, 1914.)—The author has previously shown [see Abs. 1978 (1913)] that Maxwell's velocity-distribution function holds for neutral particles but is at best an approximation for electrically charged particles. He therefore offers in place of it another which corrects Maxwell's in the right sense. This function has the advantage of harmonising the observations with the Wien-Planck spectrum equation and without the hypothesis of energy quanta.

A direct experimental proof of the velocity law is now at hand in the work of C. Ramsauer [see Abs. 1056 (1914)]. A curve is plotted from the equation $y = 650x^4(e^{2x^2} - 1)^{-1}$ and the various data are shown in dots, crosses, and circles on the diagram. The agreement is fairly good. E. H. B.

SOUND.

1712. *Mean Speed of Sound in Crystals.* **L. Hopf** and **G. Lechner.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 643–649, July 15, 1914.)—Discusses the relation between the elasticities of solids and the variation of their specific heats at low temperatures on the theories of Einstein, of Born, of Kármán, and of Debye. The calculations are carried out for sylvine, rock-salt, fluorspar. and pyrites, and show that the elastically reckoned speed of sound always slightly exceeds that based on thermal data. [See Abs. 446, 626 (1913).] E. H. B.

1713. *Effect of Radiation on Speed of Sound in Gases.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 613–614, July 15, 1914.)—A discussion of the positive effect of Röntgen rays on the speed of sound in gases observed by W. Küpper. [See Abs. 1294 (1914).] E. H. B.

1714. *Effect of Röntgen Rays on Speed of Sound in Argon.* **F. Strieder.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 615–616, July 15, 1914.)—Records experiments with Kundt's tube and cork-dust on the speed of sound in argon with and without the influence of Röntgen rays. The result is negative, the speeds with and without the rays being the same within the limits of errors. It is pointed out that the effect might be absent in a monatomic gas like argon and yet be actually present in a gas whose molecule contained more than one atom. [See Abs. 249 (1908), 1294 (1914), 1280 (1915), and preceding Abs.] E. H. B.

1715. *Explorations over Telephonic Diaphragms Vibrating under Simple Impressed Tones.* **A. E. Kennelly** and **H. O. Taylor.** (Am. Phil. Soc., Proc. 54. pp. 96–136, May–July, 1915.)—The object of the investigation was to explore the amplitude of the small harmonic vibrations of a circular diaphragm of telephonic type, clamped around the edge, and to compare the observed values with those which had already been deduced mathematically. Previously, the amplitude of vibration of a telephone diaphragm seems only to have been determined at a single point on the surface, usually the centre. The observations here reported extend over the entire surface of the diaphragms. The "explorer" devised and constructed for this research, consists of a tiny triangular mirror fastened to a little phosphor-bronze strip. This strip is parallel to the surface of the diaphragm and, by its torsion, causes one corner of the mirror to press on the spot of the diaphragm under test. The pressure exerted by the mirror on the diaphragm is so small as not materially to affect the diaphragm's vibration. Further, the natural frequency of the mirror being much greater than that impressed on the diaphragm, the mirror is able to follow the vibrations of the latter without breaking out of contact. A beam of light, reflected by the mirror on to a scale measures the amplitudes at the various points. Vibrations of the amplitude of 10^{-6} cm. could be observed. The results are given for plain and loaded diaphragms in a number of curves and tables and cannot be easily summarised. The paper includes a mathematical theory and a bibliography. E. H. B.

1716. *Sound Intensity; Deviation from Inverse Square Law.* **H. Stiles** and **G. W. Stewart.** (Iowa Acad. Sci., Proc. 21. pp. 255–256, 1914.)—The authors, by an extension of Rayleigh's theory, have calculated the effect in the neighbourhood of a rigid sphere produced by a source of sound located on that sphere. One of the results of this theoretical investigation is the establishment of the variation of the intensity of sound with the distance from the centre of the sphere. The results are given in two tables following, in which *r* is the distance from the centre of the sphere, and the angles given are those between the lines through (i) the centre of sphere and source of sound, and (ii) the centre and the point from which computation is desired. The variable shown is the number which must be multiplied into the inverse square of the distance from the centre to give the correct relation between the various intensities. The circumference of the sphere is in each case 60 cm.

WAVE-LENGTH, APPROXIMATELY MIDDLE C.

r.	0°.	30°.	60°.	90°.	120°.	150°.	180°.
19·1 cm.	6·28	3·54	1·28	0·652	0·655	0·756	0·777
477·0 ,,	1·04	1·03	1·02	1·00	0·978	0·968	0·957
1910·0 ,,	1·00	1·00	1·00	1·00	1·00	1·00	1·00

WAVE-LENGTH, APPROXIMATELY AN OCTAVE ABOVE MIDDLE C.

r.	0°.	30°.	60°.	90°.	120°.	150°.	180°.
19·1 cm.	4·24	2·58	1·14	0·622	0·396	0·329	0·270
28·6 ,,	2·26	1·81	1·18	0·728	0·564	0·446	0·420
76·4 ,,	1·75	1·58	1·15	0·862	0·661	0·544	0·520
477·0 ,,	1·00	1·00	1·00	1·00	1·00	1·00	1·00

E. H. B.

1717. *Is the Sound Speed in Gases changed by Radiation?* **K. Czukor.** (Deutsch. Phys. Gesell., Verh. 17. 15. pp. 261–268, Aug. 15, 1915.)—A mathematical examination of the possible change in the speed of sound in gases exposed to radiation, with special reference to HCl gas and Röntgen radiation. The equation of motion of the electron under these conditions is written $m \,.\, d^2x/dt^2 + a^2x + bx^2 = P(t)$. It is concluded that the ratio of specific heats, and consequently the speed of sound, may be notably increased. [See Abs. 1294 (1914); 1713, 1714 (1915).] E. H. B.

1718. *Simple Method for Sensitive Flames.* **K. L. Schaefer.** (Ann. d. Physik, 48. 1. pp. 109–112, Sept. 28, 1915.)—Describes by help of a diagram a method of obtaining a high gas pressure for sensitive flames by driving the gas out of a chamber by letting water in from an ordinary tap. Thus the chamber may be supplied at low pressure, and then the pressure raised by the admission of the water. E. H. B.

1719. *Forced Vibrations in Strings.* **A. Kalähne.** (Deutsch. Phys. Gesell., Verh. 16. 21. pp. 934–950, Nov. 15, 1914.)—A general survey of the theory of Helmholtz and the recent work of C. V. Raman. [See Abs. 1189 (1911).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1720. *Decrease of Speed of Electrified Particles in passing through Matter.* **N. Bohr.** (Phil. Mag. 30. pp. 581–612, Oct., 1915.)—The object of the present paper is to continue some calculations on the decrease of velocity of *α*- and *β*-rays published by the author in a previous paper [Abs. 1980 (1913)]. That paper was concerned only with the mean value of the rate of decrease of velocity of the swiftly moving particles, but from a closer comparison with the measurements it appears necessary, especially for *β*-rays, to consider the probability distribution of the loss of velocity suffered by the single particles. This problem has been discussed briefly by K. F. Herzfeld [Abs. 1587 (1912)], but on assumptions as to the mechanism of decrease of velocity essentially different from those used in the present work.

According to the theory now put forward, the decrease of velocity of *α*- and *β*-rays in passing through matter depends essentially on the characteristic frequencies of the electron in the atoms, the dependence being like that which obtains in the phenomena of refraction and dispersion. It was previously shown that the theory leads to results which are in close agreement with experiments on absorption of *α*-rays in hydrogen and helium, if we assume that the atoms of these elements contain one and two electrons respectively, and if their frequencies are put equal to those calculated from experiments on dispersion. It was also shown that an approximate explanation of the absorption of *α*-rays in heavier substances could be obtained if we assumed that the atoms of such elements, in addition to a few electrons of optical frequencies, contain a number of electrons more rigidly bound and of frequencies of the same order of magnitude as characteristic Röntgen rays. The number of electrons deduced was in approximate agreement with those calculated in the theory of E. Rutherford for the scattering of *α*-rays. These conclusions have now been verified by using the later, more accurate, measurements.

In the former paper very few data were available on the decrease of velocity of *β*-rays in traversing matter, and the agreement between theory and experiment was not very close. This agreement is now materially improved, partly by using new measurements and partly by taking into account the probability variations in the losses of energy suffered by the individual *β*-particles. In this connection it is pointed out that it appears that measurements on the decrease of velocity of *β*-rays afford an effective test of the formulæ for the energy and momentum of a high-speed electron deduced on the theory of relativity.

In connection with the calculations of the absorption of *α*- and *β*-rays, the ionisation produced by such rays is considered. It is shown that the theory of J. J. Thomson gives results in approximate agreement with the measurements if we take into account the secondary ionisation produced by the electron expelled by the direct impact of the *α*- and *β*-rays. E. H. B.

1721. *Einstein's Photoelectric Equation.* **R. A. Millikan.** (Phys. Rev. 6. p. 55, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—A report of work on lithium of the kind reported a year before for sodium [Abs. 202 (1915)]. Planck's *h* appears as definitely in this work on lithium as it did in that on sodium. There is a very perfect linear relationship between the p.d. and ν, and the slope of the line gives $h = 6{\cdot}585 \times 10^{-27}$, which is within four-tenths of 1 % of the value found with sodium. Einstein's equation is shown to lead to the conclusion that contact e.m.f. is independent of temperature—a result in agreement with recent experiments. E. H. B.

1722. *Elementary Electric Charge and the Photoelectric Effect.* **D. Konstantinowsky.** (Ann. d. Physik, 48. 1. pp. 57–83, Sept. 28, 1915.)—A discussion of previous work on the subject and the views to be entertained respecting it, special references being made to the investigations of E. Meyer and W. Gerlach. [Abs. 886 and 1091 (1915).] E. H. B.

1723. *The Maxwell-Lorentz Fundamental Equations of the Electron Theory.* **A. Byk.** (Deutsch. Phys. Gesell., Verh. 16. 17–18. pp. 850–874, Sept. 30, 1914.)—Mathematical. [See also Abs. 1891 (1913).]

1724. *Potentials in the Electromagnetic Field.* **K. Uller.** (Phys. Zeits. 16. pp. 876–881, Oct. 15, 1915.)—Mathematical.

1725. *Reflection and Refraction of Electromagnetic Waves.* **K. Uller.** (Deutsch. Phys. Gesell., Verh. 16. 19. pp. 875–880, Oct. 15; 21. 926–930, Nov. 15, and 23. pp. 997–1011, Dec. 15, 1914.)—The author has previously treated of elastic waves [Abs. 1607 (1915)], and now extends his mathematical treatment to the case of electromagnetic waves. L. H. W.

1726. *Electric Falls, Stokes' Law and the Removal of Particles from Fluids.* **W. W. Strong.** (Ann. d. Physik, 48. 2. pp. 251–260, Oct. 14, 1915.)—Discusses the passage of gases through a cylinder at the centre of which is a highly charged wire; thus the gases may be freed from suspended dust, mist, or smoke particles. A smoke remover on this principle is in use in the University of Pittsburg. [See Abs. 931B (1913), and 182B (1915).]

E. H. B.

DISCHARGE AND OSCILLATIONS.

1727. *Mobilities of Ions in Air at High Pressures.* **J. C. McLennan** and **D. A. Keys.** (Phil. Mag. 30. pp. 484–491, Oct., 1915. Paper read before the Roy. Soc. of Canada, May, 1915.)—In a previous paper [Abs. 520 (1914)] the authors drew attention to the importance of making measurements on the mobilities of ions, both in liquid air and in air at very high pressures. Attempts to measure the mobilities of ions in liquid air were unsuccessful. Measurements in air at high pressures have proved, however, more satisfactory, and the mobilities of the two kinds of ions, positive and negative, over a pressure range of 67 to 182 atmos. have been investigated. At the lower pressures of this range the mobilities obtained agree with those of Kovarik (1912), but at the higher pressures it was found that the mobilities of the two kinds of ions began to approach each other in value and both decreased less rapidly with increases in pressure than is to be expected on the inverse pressure law. The departure from this law is, however, not very great.

The results seem to give support to the view that the mobilities of the positive and negative ions will be equal in liquid air, but further measurements at higher pressures are necessary before this deduction can be verified. A. B. W.

1728. *Mobility of Positive and Negative Ions at Different Temperatures and Constant Gas Density.* **H. A. Erikson.** (Phys. Rev. 6. pp. 345–358, Nov., 1915.)—Phillips and Kovarik [Abs. 1755 (1906), 966 (1910)] independently showed that a change in the sizes of positive and negative ions in air takes place at temperatures below 0° C. They worked with constant gas pressure, and their results do not necessarily hold when the gas density is kept constant. The author measures the mobility of the positive and negative ions in air (both dry and moist) at temperatures between —21° C. and 63° C. by an alternating field method. It is found that the mobility of the positive ion under the conditions used is a maximum about 0° C. That of the negative ion also shows a maximum, but is more erratic in its behaviour. No definite conclusion is reached, but it seems that the variation of positive mobility is not due to clustering. The variation of negative mobility seems to be due to clustering combined with an effect similar to that causing the variation of the positive mobility. T. H.

1729. *Ionic Mobilities in Hydrogen and Nitrogen.* **W. B. Haines.** (Phil. Mag. 30. pp. 503–509, Oct., 1915.)—The mobilities of free electrons in pure nitrogen at atmospheric pressure have been measured, and the effect on them of various impurities has been tested. The method adopted was the modification of Rutherford's method described by Franck, depending on the use of an experimental chamber. In some cases only a minute trace of a foreign gas is required completely to prevent the appearance of the free electrons. In nearly all cases their life in the free condition, as measured by the mobility, is much reduced by small proportions of the impurity. In nitrogen the mean value obtained for the mobility was 367 cm./sec. per volt/cm. In one series of experiments, where the conditions were exceptionally favourable, the values 438 and 509 were obtained. With an initial mobility of 158 the addition of 0·7 % of oxygen reduced the mobility to 11. Some gases are much more effective than others, and a few have such an immediate effect that after the first traces have been added no electroniç carriers at all can be detected. Hydrogen was also found to belong to the list of gases in which free electrons can exist at atmospheric pressure. The hydrogen must be purified with great care to obtain this result. Under these conditions other negative ions of high mobility appear, for which measurements have been made. Results published recently by Wellisch show that electrons appear in dry air at pressures below 10 cm.

A. M. Tyndall. (Phil. Mag. 30. pp. 743–744, Nov., 1915.)—Tyndall points out that Haines' results confirm and amplify some measurements published in 1910 by Chattock and Tyndall. Experiments on the pressure of the electric wind from a discharging point in very pure hydrogen led to a value for the mobility of 280 cm./sec. per volt/cm. The influence of the addition of known percentages of oxygen in reducing the mobility of the negative ions was studied, the percentages added ranging from 0·0002 to 8·7. The effect of these additions on the mobility of the positive ions was shown to be nil [see Abs. 1212 (1911)]. A. W.

1730. *Ionisation of Hydrogen by X-rays.* **G. Shearer.** (Phil. Mag. 30. pp. 644–658, Oct., 1915.)—In many ways hydrogen occupies a somewhat anomalous position among the elements. According to a recent theory of Bohr [Abs. 1930 (1913)] it consists of a positively-charged nucleus around which rotates a single electron—the simplest case known; hence it might be expected that a study of this gas would lead to conclusions of great theoretical interest. The work discussed in this paper was an attempt to measure the ionisation produced in hydrogen by X-rays, the work being partly suggested by the wide divergence in the results obtained by other investigators. After reviewing the work of earlier observers on the relative ionisations produced by X-rays in air and hydrogen, the author considers more in detail the experimental results of Crowther [Abs. 1227 (1909)] and Beatty [Abs. 1475 (1910)]. It is clearly brought out that impurities such as AsH_3, even when present in extremely minute quantities, exert a marked effect on the ionisation produced in hydrogen. The method of investigation was, generally speaking, like that used by Beatty (*loc. cit.*). From the curves and tabulated observations given in the paper it is shown that the ionisation of *pure* hydrogen relative to that of air is very small. The important part played by impurities is shown by the fact that about one part in 40,000 of a heavy substance such as AsH_3 would be sufficient to account for the observed ionisation. In view of these facts, the author is led to the conclusion that the values given (0·0018 for Cu rays and 0·0085 for Sn rays) in the table are *upper limits* to the value of the ionisation of hydrogen relative to that of air. Taking the mean of the three lowest values obtained, the upper limit values for the ratio of the ionisation of hydrogen to the ionisation of air are 0·0010 for Cu rays and 0·0016 for Sn rays. These values are much lower than any hitherto published, and there is, the author considers, a very strong probability that they are overestimates. There is no conclusive evidence that the relative ionisation of hydrogen increases with a decrease in wave-length.

The work concludes with a theoretical discussion of the question, the work of Bohr (*loc. cit.*) on the hydrogen spectrum being carefully examined.

A. B. W.

1731. *Dependence of Photoelectric Charging-up Potential on the Material.* **E. Gehrcke** and **L. Janicki.** (Ann. d. Physik, 47. 5. pp. 679–698, Aug. 5, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—These experiments relate to the photo-effect with metal surfaces which are looked upon as clean owing to previous kathode scattering, the metal plates having been used as kathode in a discharge tube. The metal chiefly used is Pt-foil 0·01 mm. thick. Two similar plates are employed in the same cell. Under the influence of ultra-violet light no charging up of either plate occurs, when the other plate and all other metal parts of the cell are earthed, if a gas such as H, He, or water-vapour is present. When the gas is removed a positive charging up takes place the amount of which increases with the decrease in pressure. In the best obtainable vacuum the potential reaches a final value which is independent of the degree of the vacuum, in so far as it is affected by small differences produced by cooling a small side branch of the tube in liquid air in place of liquid hydrogen, etc. If one of the plates is positively or negatively charged it can be discharged in a few seconds, if any gas is present, by allowing the light to act on the cell. In a high vacuum the plate acted on by light takes up a positive potential. The value of this potential obtained with plates which had not previously been subjected to kathode scattering was generally not uniform, and the value altered with the duration of the lighting. By allowing the plate to remain in the dark these alterations were sometimes, but not always, annulled. The positive potential to which the plates charge up depends upon the gas in which the kathode scattering has taken place. With water-vapour, oxygen, or helium the values vary between 0·87 and 1·57 volts, while with hydrogen it always approximates to 1·15 volts. Gold plates give similar qualitative results to Pt. These experiments were carried out with a small cell the walls of which were removed only a few cm. from the metal. In order to avoid the action of reflected light similar experiments are made with a larger cell. The final value of the potential is now found to be essentially higher in all cases, that with hydrogen being 2·82 volts. With gold, copper, and zinc the rate of charging up and the potential to which the electrodes charge up do not depend essentially on the metal employed. With Al a potential of only about 1·7 volts is obtained. Reasons are given for the statement that the photo-electrons which are set free most quickly from the metal are not from the metal atom but from the hydrogen occluded in the metal, and a theory of the photo-effects obtained with a hydrogen-laden metal is developed. A. E. G.

1732. *Selective and Normal Photo-electricity of Potassium.* **G. Wiedmann.** (Deutsch. Phys. Gesell., Verh. 17. 16. pp. 348–349, Aug. 30, 1915.)—It has previously been shown that potassium cells obtained by distilling many times in gas at very low pressure have only 1 % of the sensitivity of those prepared in the usual way [Abs. 722 (1914)]. On the other hand, a repetition of the experiments by Pohl and Pringsheim [Abs. 1306 (1914)] failed to find any smaller photo-electricity in the region of greatest selective action than that obtained from potassium in the usual manner. These contradictory results made it necessary to repeat the research under wider and better conditions. It is now found that with the specially prepared potassium the photoelectric sensitivity sinks to less than 1 % of its original value, and that the selective action of potassium in its suitable wave-length region vanishes. A. E. G.

1733. *Influence on the Photoelectric Effects when Palladium is charged with Hydrogen.* **F. Stumpf.** (Deutsch. Phys. Gesell., Verh. 16. 22. pp. 989–994, Nov. 30, 1914.)—The fact that occluded gas contained in a metal very essentially influences its photoelectric behaviour has been emphasised a good deal lately. T. Wulf [Abs. 658 (1908)] found that platinum charged electrolytically with hydrogen is 10 times as sensitive as when charged with oxygen. Holman, Chrisler, and Greinacher have also carried out experiments on the sensitivity of Pt when hydrogen has been absorbed by it, and the results obtained are not in agreement. As palladium has an especially high power of taking up hydrogen, experiments are now made with that metal. Although the values obtained in the various series of observations are not markedly comparable, yet they point to the conclusion that the sensitivity of the Pd charged with the gas is about 10 times greater than that of the uncharged metal. A. E. G.

1734. *Photoelectric Effects with Metals when using the Glow-discharge.* **E. Wertheimer.** (Deutsch. Phys. Gesell., Verh. 17. 15. pp. 289–305, Aug. 15, 1915.)—The present work forms a continuation of that of Greinacher on the influence of the glow-discharge on the photoelectric effect. Experiments with other metals and on the quantitative examination of the effects are now carried out. In particular it is endeavoured to determine under what condition the photoelectric current reaches its max. value. The apparatus employed is described in detail and the results obtained are grouped as follows:—The influence of moisture on the photoelectric effect: The photoelectric effect after using the glow-discharge: Recovery and fatigue appearances especially with Cd and Pb. The experiments with Mg, Zn, Cd, Pb, Sn, Bi, Ni, Fe, and Cu indicate the previously known fact that the photoelectric current is greatly reduced by a change of the surrounding gas, *e.g.* a change from the moist air of the room to dried air or hydrogen (dry or not dry). In opposition to this it is found that there is an increase of the effect with Ag when the room air is changed for hydrogen. The largest values obtained with air are increased by means of the glow-discharge in hydrogen in the cases of Zn, Cd, Pb, Sn, Bi, Ni, Cu, Ag, Pt, Pd. With Cd it has been possible to obtain qualitative recovery and fatigue curves showing two maxima. The results taken as a whole seem to indicate that the photoelectric current depends upon two variables that are independent of one another, one variable being the condition (purity) of the metal surface, and the other the condition of the surface water-film. A. E. G.

1735. *Persistence of the Current in Photoelectric Cells after the Suppression of the Exciting Light.* **O. M. Corbino** and **G. C. Trabacchi.** (N. Cimento, 10. pp. 47–67, July–Aug., 1915.)—After the discontinuance of the light impinging on a photoelectric cell subjected to a p.d., a residual current persists; this is still detectable after the lapse of a period of the order of one-hundredth of a second, and diminishes the more rapidly the higher the p.d. applied. Thus, with a p.d. of about 50 volts, the current has about 0·085 times its normal value 0·05 sec. after the action of the light ceases. This residual current is due, not to posthumous emission of ions by the metal, but to the presence in the cell of ions created by shock which give rise to new ions before they are transferred to the electrodes. T. H. P.

1736. *Spontaneous Electron Emission from Glowing Metals and the Glow-electric Element.* **W. Schlichter.** (Ann. d. Physik, 47. 5. pp. 573–640, Aug. 5, 1915.) — After a brief introduction the following are the chief sections considered :—Relation of the present work to the researches which have taken place up to the present: Experiments on the spontaneous glow-electric emission; results obtained when using platinum; results obtained with nickel: The glow-electric element. The conclusions arrived at are that the glow-elements, as such, are possible. It is, however, quite uneconomical to use them on account of the disproportionately high radiation loss. A. E. G.

1737. *A New Group of Electric Light Appearances.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 17. 14. pp. 256–258, July 30, 1915.)—By the discharge of a Leyden jar which is fed by an inductor, a new kind of kathode ray is generated which differs in several particulars from the usual kathode rays. One of the most striking differences is the peculiar colour of the rays. These "jar rays" are also found to be much longer than the usual rays obtained with an inductor discharge at the same gas pressure; they are also less easily absorbed, and also less easily deviated by a magnet than ordinary kathode rays under like conditions. A. E. G.

1738. *Current-potential Curve for the Electric Light Effect.* **K. Hermann.** (Deutsch. Phys. Gesell, Verh. 16. 14. pp. 683–687, July 30, 1914.)—If, in an electric light apparatus, a test electrode is introduced behind the kathode, the test electrode being shielded from direct light, a loss of negative charge can be observed. Curves are here given showing the current from such a test electrode as a function of the field between the electrode and the neighbouring wall. The variations which the curve undergoes for different degrees of vacuum and for different materials of wall and electrode are also illustrated and the results are discussed. A. W.

1739. *Critical Field at a Discharging Point.* **A. M. Tyndall.** (Phil. Mag. 30. pp. 637–644, Oct., 1915.)—It has been shown theoretically by Townsend that if X is the critical field—namely, the field at the start or cessation of discharge—at the surface of a point of radius a, at a pressure p, then Xa is constant so long as ap is constant. Direct determinations of the critical field by measurement of the mechanical force on a hemispherical point are shown to be in complete agreement with the theory. An expression for the critical field as a function of pressure and radius of point, deduced on certain assumptions by Edmunds [Abs. 1876 (1914)], is shown to be in reasonable agreement with the experimental values given in this and a previous paper [Abs. 1482 (1910)]. Further measurements of the field at a point under varying conditions of discharge have been made; the effect of supplying the point with ions of a given sign from an external source is briefly discussed in the light of the theory of collisions. A. B. W.

1740. *Polarisation of Short Hertzian Waves by Metallic Gratings.* **H. Behnken.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 617–635, July 15, 1914. Extract of Dissertation, Berlin.)—Wave-lengths of 188, 72, 29, and 14 mm. were used, and the results obtained are shown in over 20 graphs and a number of tables. They were compared with those of Du Bois and Rubens, and some of them show complete agreement. [See Abs. 1696 (1911).] E. H. B.

1741. *Potential Curves for Röntgen Tubes.* **A. Wehnelt.** (Ann. d. Physik, 47. 8. pp. 1112–1126, Sept. 27, 1915.)—Potential curves were obtained for Röntgen tubes by means of a Braun tube, and show the phenomena typical of sharply cut-off partial discharges. The potential rises during one phase up to the discharge potential, when the discharge takes place. The resistance of the tube is then very small, so that relatively large currents are possible. On account of the large self-induction of the coil, however, these large currents do not exist, and the potential at the ends of the coil sinks at the discharge to only a small fraction of the normal potential. At this sudden fall of potential the discharge ceases, and at the next current-reversal the potential begins to rise slowly again until the discharge potential is reached, when the process is repeated. If the tube is very hard, only one or perhaps two discharges pass during one phase. With soft tubes repeated sharply-defined partial discharges take place, and these, with the employment of stronger currents, take on sometimes a less defined character after one or more sharply-defined discharges have taken place. The form of the potential curves can be explained from the characteristics of the curves for the primary current of the induction coil. From the latter it is seen that the sharp partial discharges correspond to sudden increases of the primary current. [See also Abs. 1691 (1908) and 1744 (1914).] A. W.

1742. *Use of the Photoelectric Cell as a Receiver in Wireless Telegraphy.* **H. Behnken.** (Deutsch. Phys. Gesell., Verh. 16. 13. pp. 668–678, July 15, 1914. From the Physikal.-Techn. Reichsanstalt.)—After referring to the inconstant sensibility of contact detectors, the author describes an arrangement for measurement purposes; this includes a photoelectric cell as detector, for which a sensitiveness comparable to that of the galena detector is claimed together with complete indifference to atmospheric discharges. The photoelectric cell is of special construction, great care being taken to keep the Pt anode from being contaminated by the potassium used as kathode. A Wulf string electrometer is used as recording instrument and examples of records of radiotelegraphic time-signals are reproduced. As the electrometer is a potential-operated device, better results are obtained by using a step-up oscillation transformer. The scheme of connections is particularly simple, the cell being in series with the transformer secondary and the electrometer fibre, and the sectors of the electrometer being connected to one pole of the auxiliary charging battery whilst the other pole is earthed. In practice it is found that on closing a shunt circuit leading from the fibre to earth a deflection is obtained when the cell is exposed to light (or to the oscillating potential) and this should be compensated for by earthing the other end of the transformer secondary through an adjustable portion of a neutralising potentiometer circuit. The electrometer then has a constant zero reading. L. H. W.

1743. *Electric Oscillations in Coupled Circuits—A Class of Particular Cases.* **W. H. Eccles** and **A. J. Makower.** (Engineering, 100. pp. 283–284, Sept. 17, 1915. Paper read before the British Assoc., 1915. Electrician, 75. pp. 905–907, Sept. 24, 1915. Lum. Élec. 31. pp. 231–235, Dec. 4, 1915.)—The authors discuss the coupling of two circuits and describe a method of coupling in which this is effected wholly or partially by condensers. In this case the frequencies of the two waves generated depend on entirely new formulæ which are worked out by the authors, and the conditions are investigated under which these circuits may give rise to oscillations of a single frequency. As the paper is almost wholly mathematical it cannot be usefully abstracted. I. W.

1744. *Quenching Processes in Spark-gaps.* **H. Masing** and **H. Wiesinger.** (Phys. Zeits. 16. pp. 185–191, May 1 and 15, 1915.)—The authors have attacked the problem from H. T. Simon's point of view that a single spark discharge is a high-frequency a.c. arc. The experimental arrangement consisted of two oscillatory circuits, I and II, connected in parallel to the same spark-gap, the gap electrodes being directly connected to the secondary of the spark-coil. A measuring circuit with Hahnemann wave-meter and hot-wire wattmeter was arranged so that it could be shifted in such a way as to be coupled to one or other of the circuits I, II. The two circuits are slightly mistuned, and as a result of the beats caused by the frequency-difference of the two circuits a decrease of the current amplitude takes place, which leads to an extinction of the spark. At this instant the partial oscillations in I and II are in such a phase relation that they are able to continue oscillating in series, and as the circuits are purely metallic the damping must be smaller than that of the partial oscillations. Further experiments showed that in order to obtain slightly damped oscillations a Wien quenched-spark gap is unnecessary: they may be obtained with any sort of gap. It is, further, found that for a certain critical ratio, λ_{I}/λ_{II}, the spark is extinguished after the first beat. No investigation was made of the efficiency of the method or of its suitability for use with greater amounts of energy. Reference is made to Seibt, Macku, and Settnik and Rukop, who had proposed apparently similar methods, but which the authors show are really the same as Wien's. L. H. W.

1745. *Production of Undamped Electric Oscillations by Quenched Spark Dischargers.* **H. Yagi.** (Electrician, 76. pp. 195–197, Nov. 12, 1915.)—Following Chaffee [Abs. 1258 (1912)], the author has made observations on the behaviour of an Al-brass gap in an atmosphere of coal gas, and found similar results. L. H. W.

1746. *Electric Waves in Air and along Wires.* **M. Ehrhardt.** (Ann. d. Physik, 47. 6. pp. 809–831, Aug. 17, 1915.)—An experimental research which showed a good agreement between the wave-lengths in air and along wires, identical values (50·8 cm.) being repeatedly obtained of the half-wave lengths in air and on the wires. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1747. *Flow of Electricity through Dielectrics.* **S. W. Richardson.** (Roy. Soc., Proc. 92. pp. 41–57, Oct. 1, 1915.)—The author has investigated the residual discharge in Iceland spar, quartz, rock-salt, and other substances. According to Rowland and Nichols, Iceland spar does not exhibit the phenomenon of residual discharge, but the author finds conclusive evidence of its presence. He describes fully how small quantities of electricity escaping from a dielectric can be measured. The author's conclusions include the following:—When a p.d. is applied to a dielectric it becomes polarised. If the p.d. is suddenly removed the polarisation dies away rapidly at first, but more slowly afterwards. It is the decay of this polarisation that gives rise to the so-called *instantaneous* and *residual* discharges of a condenser. (2) Let one surface of a dielectric be permanently earthed and the other surface be maintained at potential V for a time T. If this second surface is now earthed, after a very short time (τ) the charge set free is KCV, where C is a constant and K is, in general, sensibly independent of both V and T. (3) There is a charge remaining in the dielectric, which slowly dies away, and this charge can at any time, *t*, from the commencement of the discharge be represented by K'_tCV, where K is the specific inductive capacity and K'_t the specific inductive residual capacity. The total initial charge in the dielectric is $(K+K'_t)CV$. The relation of K'_t to the time, and the influence of time of changing are discussed. Full details of the work are given in the tables and graphs.

(Ibid. pp. 101–107, Nov. 1, 1915.)—Curie and others have shown that when a condenser is charged by a steady p.d. the charging current diminishes as the time of charging increases. The author's observations on glass, paraffin, ebonite, quartz, and Iceland spar agree with this conclusion. The author has also found that if (during charging) the applied e.m.f. E is suddenly reduced to E′, then, provided that $E' >$ a certain value P, a current flows through the specimen in the same direction as the original charging current, but that if $E' < P$ a current flows (for some time) in the opposite direction to the charging current. P is taken as a measure of the e.m.f. of polarisation; it increases with the time of charging very rapidly at first, but more slowly afterwards. From the data given in the preceding paper the author has calculated the relation $\gamma = dQ/dt + (E-P)/R$, where $\gamma =$ charging current, $dQ/dt =$ rate at which the charge is accumulating in the dielectric, and $R =$ true electrical resistance of the specimen. In the case of quartz the values of R obtained in this way, for times of charging varying from 10 secs. to 20 mins., are in general agreement. The results for Iceland spar seem to indicate a diminution in the value of R as the time of charging increases, but this apparent diminution may be due to inaccuracies in the data. I. W.

1748. *The Thermoelectric Properties of Carbon.* **W. C. Moore.** (Am. Chem. Soc., J. 37. pp. 2082–2087, Sept., 1915.)—An investigation of the thermoelectric properties of a number of commercial arc carbons. These were combined one with another, the junction being heated by a Méker burner and the free ends connected to a millivoltmeter. Except when the carbons were of the same kind, an e.m.f. was developed: in one case, 7·25 millivolts, after 42 minutes' heating to low redness. Another set of experiments consisted in measuring the thermoelectric force of various carbons combined with copper, the design of the couple being such as to prevent burning of the carbon and oxidation of the copper. One junction was heated in a furnace and the other water-cooled. The results for three typical couples are given in the paper. The magnitude and sign of the effect varies with the couple. In two cases a max. e.m.f. was obtained which remained constant over a considerable temperature-range. The author concludes that the differences are in general due to the difference in raw materials used and in the manufacturing history. The long temperature interval of constant e.m.f. and the change of direction of the temperature-coefficient suggest to the author that possibly some constituent of the carbon is passing through a transition interval. L. L.

1749. *Piezoelectric Effect excited by Torsion and Bending.* **W. Voigt** and **V. Fredericksz.** (Ann. d. Physik, 48. 2. pp. 145–176, Oct. 14, 1915.)—The authors investigate theoretically the piezoelectric effect produced when a circular cylinder of a crystal belonging to the enantiomorphous group of the trigonal system is subjected to (1) torsion, (2) bending. Three cases are dealt with, the axis of the cylinder being (1) parallel to the principal crystallographic axis, (2) parallel to a lateral axis, (3) normal to the principal and lateral axes. Theory shows that in the first case when the cylinder is subjected to torsion there should be no piezoelectric effect and the authors ascribe the effect previously observed by Röntgen with a crystal of quartz to be due to incorrect orientation of the crystal. The theoretical results obtained in cases (2) and (3) have been experimentally confirmed by observations on quartz cylinders, 1·20 cm. diam., 16 cm. long; and 1·09 cm. diam., 18 cm. long. In case (3) the confirmation is not so good as in case (2), but this is to be ascribed to the large error introduced by a slight change in the orientation of the crystal. When the crystal is subjected to bending theory shows that a piezoelectric effect is only obtained when the axis of the cylinder is normal to the principal and lateral axes. This is verified experimentally. The inverse phenomena, the twisting or bending of the crystal when subjected to an electric field, are also investigated theoretically. The authors find that (1) when the principal axis coincides with the axis of the cylinder there is no strain: (2) when the axis of the cylinder is coincident with a lateral axis the crystal experiences a torque: (3) when the axis of the cylinder is normal to the principal and lateral axes the crystal experiences bending and twisting. The experiments made by the authors confirm these theoretical results. L. L.

1750. *Investigation of the Interior of the Earth's Crust by Electric Waves and Oscillations.* **G. Leimbach.** (Zeits. Vereines Deutsch. Ing. 59. pp. 771–774, Sept. 18, 1915.)—In this paper some examples of the different processes detailed previously [Abs. 1324 (1915)] are given together with the practical results. It is not practicable usefully to abstract the paper. H. H. H.

1751. *Distributed Capacity of Single-layer Solenoids.* **J. C. Hubbard.** (Phys. Rev. 6. pp. 58–59, July, 1915. Abstract of paper read before the Am. Phys. Soc., April, 1915.)—A preliminary note of a detailed report shortly to be published. The distributed capacity of the coil plus the capacity of the leads is determined by measuring the period of oscillation of the coil connected with an air condenser. The capacity of the leads is then measured directly or the two are separated by making another determination with a similar solenoid in which all linear dimensions are increased *n* times, so that the distributed capacity is now *n* times as great. The distributed capacity in electrostatic units is found to be a number of the same order as the radius of the solenoid in cm. It varies only slightly with the axial length, number of turns, and diam. of wire. W. H. G.

1752. *A Case of Sine-vibrations in which the Braking Force varies Non-linearly.* **A. Kalähne.** (Ann. d. Physik, 48. 2. pp. 261–268, Oct. 14, 1915.)—The author has investigated a number of cases in which the displacing and the braking forces are not proportional to the first power of the displacement and velocity respectively. If we substitute a time function $\phi(t)$ for the index of e in the ordinary equation for exponentially damped sine-vibrations, writing it $x = Ae^{\phi(t)} \sin(\nu t + \theta)$ the acceleration equation becomes $d^2x/dt^2 - 2\phi'(t) \,.\, dx/dt - [\phi''(t) - \nu^2 - \phi'(t)^2]x = 0$. By suitably choosing the function $\phi(t)$ equations are obtained for vibrations in which the forces do not vary linearly with the displacement or velocity. The paper presents the case where the braking term is $4\delta' x^2 \,.\, dx/dt$, *i.e.* is proportional to the square of the displacement as well as to the velocity. As an example, the author takes a coil vibrating in a magnetic field which has a maximum at the normal position of the coil, and varies in strength in each direction in accordance with $H = H_0 - ax^2$, where a is a constant and x the deflection. W. H. G.

1753. *Simple Resonance Experiment.* **O. Steels.** (Phil. Mag. 30. pp. 623–627, Oct., 1915.)—Describes the forced vibrations of a compass needle near a coil with an alternating current, an electromagnet with a steady current being used for control of the needle. The mathematics of the phenomenon is given also. E. H. B

1754. *Mechanical Model of an Electrical Transmission Line.* **F. Breisig.** (Elekt. Zeits. 36. pp. 521–524, Oct. 7, 1915. Communication from the German Telegraphs Experiment Station.)—A description of a mechanical model capable of illustrating surges in transmission lines. A model previously described by Fleming [Abs. 1867 (1913)] was able to reproduce periodic oscillations, and the present model has the additional property of reproducing aperiodic oscillations also. The apparatus consists of rods connected together elastically by springs. The ends of the rods turned towards the observer are painted white, so that their positions may be clearly marked. Instantaneous photographs are given showing surges in process of transmission. By loading individual rods the properties of Pupin cables can be shown. A. J. M.

1755. *Lilienfeld's X-ray Tube.* **F. J. Koch.** (Fortschr. auf dem Gebiete der Röntgenstrahlen, 23. May, 1915. Elektrot. u. Maschinenbau, 33. pp. 466–467, Sept. 19, 1915. Abstract.)—After considering the difficulties of obtaining a powerful X-ray discharge from an ordinary type of X-ray tube, the advantages of the use of a Wehnelt kathode are emphasised. In the Coolidge and Lilienfeld X-ray tubes, in which a Wehnelt hot-lime kathode is used, extremely intense and penetrating beams of X-rays can be produced without the usual troubles due to the "gassing" of the tube at high p.d.'s. A description of the Lilienfeld form of tube is given. A. B. W.

ALTERNATING CURRENTS AND MAGNETISM.

1756. *Paramagnetic Determinations and Possible Existence of Energy at Absolute Zero.* **R. Gans.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 780–788, Aug. 30, 1914.)—Discusses the work of Oosterhuis and others as to the magnetic measurements of paramagnetic substances, especially crystalline and anhydrous manganic sulphate. The author feels that the inference from the work of Oosterhuis that the observations yield evidence for the existence of energy at the absolute zero is premature. [See Abs. 1449 (1906).]

E. H. B.

1757. *Magnetic Quality of Iron and Steel as affected by Transverse Pressure.* **W. J. Walker.** (Roy. Soc. Edinburgh, Proc. 35. pp. 217–224, 1914–1915.)—The materials used in this investigation were cast iron, soft wrought iron, and steel in the form of rods 20 cm. long and 2 cm. diameter. A length of 6·5 cm. in the centre of each specimen was filed square and the pressure was applied to two opposite faces of this portion. Various pressures were applied up to 50 tons per sq. in. After each compression the specimen was demagnetised and its B-H curve determined. The results are given in a series of curves in the paper.

L. L.

1758. *Magnetic Properties of Heusler Alloys.* **E. Take** and **A. Semm.** (Deutsch. Phys. Gesell., Verh. 16. 22. pp. 971–988, Nov. 30, 1914.)—An experimental investigation of alloys of Sn, Mn and Cu, from which the authors seek to adduce evidence in support of Heusler's theory [Abs. 255 (1913)], according to which the magnetic properties of these alloys is to be ascribed to the presence of compounds of the form $Sn_x[(MnCu)_3]_x$. Two series of alloys were prepared, the first by adding varying amounts of Sn to a manganese bronze containing 30 % Mn, and the second by adding Sn to a 15 % manganese bronze. The chief results are given in the tables, the magnetising field being 1000 c.g.s.

SERIES I.—30 % *Manganese Bronze.*

Atomic Composition.		SnM_2	$SnM_{2·75}$	SnM_3	$SnM_{3·5}$	SnM_4	SnM_5	SnM_6	SnM_9	SnM_{12}	SnM_{18}
Intensity of Magnetisation	Initial............	41	418	405	49	53	24	0	0	0	0
	After 1500 hrs. at 110° C. ...	34	263	286	41	37	22	0	150	90	60

SERIES II.—15 % *Manganese Bronze.*

Atomic Composition.		SnM_2	SnM_3	SnM_4	SnM_9
Intensity of Magnetisation	Initial	25	102	10	7·5
	After 1500 hrs. at 110° C. ...	19	68	9	8

These show a max. effect for composition $Sn(MnCu)_3$. An alloy of Sn and a 7·5 % bronze was also prepared of the atomic composition SnM_3. This gave I = 8 after ageing. Of alloys examined by Ross and Gray, one with 88 % Sn, corresponding approximately to SnM_3, was the most strongly magnetic [Abs. 890 (1911)].

The authors also find that the transition temperature for these alloys, which lies initially between 240° and 285° is, unlike the Al series, very slightly affected by ageing for 1500 hours at 110° C., or by quenching from 600°, or by slow cooling from 800°. Curves are also given in the paper showing the effect of ageing on the intensity of magnetisation for different field strengths. The general conclusion to be drawn is that these alloys have initially a high magnetic value, which, although subject to small fluctuations at first, soon attains a stable value even in the highest field. L. L.

1759. *An Approximate Law of Susceptibility.* **W. Steinhaus** and **E. Gumlich.** (Deutsch. Phys. Gesell., Verh. 17. 15. pp. 271–288, Aug. 15, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—Reasons are given for the view that reversible magnetic changes, such as are observed in ferromagnetic crystals, have an influence on magnetisation, both during the initial stage and during the approach to saturation. The dependence of the "reversible susceptibility" (*i.e.* the value of $\Delta I/\Delta H$ after many reversals of the small step ΔH) on the intensity of magnetisation, is expressed by means of an approximate law obtained from an equation given by Gans. The law was tested for soft iron, soft steel, cast iron, and Heusler alloy; of these, cast iron gave the best confirmation of the law. G. E. A.

1760. *Variation of Resistance in the Magnetic Field and the Hall-effect in Pastilles of Bismuth Powder.* **G. C. Trabacchi.** (N. Cimento, 10. pp. 68–71, July–Aug., 1915.)—The resistance of bismuth is found to be increased in the ratio 1·20 : 1 in a magnetic field of 5400 c.g.s. units, whilst, when the Bi is finely powdered and then compressed into pastilles, the variation in the resistance produced by this field is only in the ratio 1·04 : 1. If the metal is obtained by compressing the fine powder produced by chemical reduction of a bismuth salt, the variation of the resistance is practically zero, even with a field of 10,000 gauss. These variations are not accompanied by any change in the Hall-effect. T. H. P.

1761. *Magnetisation by Rotation.* **S. J. Barnett.** (Phys. Rev. 6. pp. 239–270, Oct., 1915.)—(1) On the electron theory it is shown that by a sort of molecular gyroscopic process a body of any substance set into rotation becomes the seat of a uniform intrinsic magnetic intensity parallel to the axis of rotation, proportional to the angular velocity, and directed, provided the effect of the negative electrons is preponderant, oppositely to the intensity which would be produced by an electric current flowing round the body in the direction of rotation. If the substance is magnetic, magnetisation results; otherwise not. If only the negative electrons are involved, the intensity per unit speed has its max. numerical value and is calculated to be $H/n = -7{\cdot}0 \times 10^{-7}$ gauss/revs. per sec. (2) The theory of the converse effect (rotation by magnetisation) is developed in a simple manner. (3) An extended series of experiments on the magnetisation of steel rods by rotation is described. All suspected sources of systematic error have been eliminated by the elaborate precautions taken, and it is believed that the effect predicted by theory has been discovered. The method of electromagnetic induction was used, a fluxmeter, whose deflections were read to tenths of a mm. at the scale distance 8 m., being the chief measuring instrument. The intrinsic magnetic intensity of rotation, and the change of magnetic flux density, per unit speed were found to be about $-8{\cdot}1 \times 10^{-7}$ gauss/revs. per sec. and $-1{\cdot}9 \times 10^{-5}$ (maxwell/cm.^{2}) per rev. per sec. respectively. Experiments made by Lebedew for a different purpose are quoted as showing that non-magnetic substances are not magnetised by the process by which iron is here shown to be magnetised. (4) The intensity of magnetisation produced in the rotating iron per unit speed was about $1{\cdot}5 \times 10^{-6}$ c.g.s. unit per rev. per sec.

If the rod had been rotated at the speed of the earth, viz. $1 \div 86{,}400$ rev. per sec., its intensity of magnetisation would have been about 2×10^{-11} of that of the earth. This, however, does not prove that the earth's magnetisation may not be due largely to the effect in question, as we are entirely ignorant of the magnetic properties of all substances under the conditions prevailing within almost the whole of the earth. [See Abs. 1466 (1915).]

E. H. B.

1762. *Effect of Temperature and Density on the Specific Susceptibility of Paramagnetic Substances.* **R. Gans.** (Deutsch. Phys. Gesell., Verh. 16. 22. pp. 964–970, Nov. 30, 1914.)—The author has recently given a formula for the specific susceptibility χ of a paramagnetic substance as a function of the absolute temperature T, viz. $\chi = \chi_0 F(\mu A/kT)$ in which A is the molecular field, μ the moment of the magneton, and k a universal constant ($1{\cdot}35 \times 10^{-16}$). χ_0 the susceptibility at the absolute zero of temperature is $2N\mu/3A$, where N is the number of magnetons per unit mass. In deriving this formula the density was assumed constant. This is sufficiently accurate for solid bodies and the theory agrees with experimental values for solids down to quite low temperatures. The experimental results of Onnes and Perrier on the susceptibility of mixtures of oxygen and nitrogen are not in agreement with the theory of Langevin [Abs. 1142 (1914)] since according to this the specific susceptibility should be independent of the density and become infinite at the absolute zero. In the present paper the author modifies his theory to take into account the density (ρ) of the material. He assumes $A = B\rho$, where B is a constant independent of temperature and density and obtains $n = n_0 F(\mu B\rho/kT)$. n $(= \chi\rho)$ is the susceptibility of unit volume and $n_0 = 2N\mu/3B$. A comparison is made in the paper between Onnes and Perrier's experimental values for mixtures of oxygen and nitrogen, and the values calculated on this theory. A similar comparison is made for $MnSO_4$ (anhydrous and crystallised). The calculated values agree with the experimental except at very low temperatures and very strong molecular fields, *i.e.* the formula fails when the vibration-frequency of the magneton is large and at the same time the temperature low. The author does not consider the theory as yet entirely satisfactory. It is derived on the supposition of the law of equipartition and needs correction in light of the quantum theory. In addition, the theory in its present state leads to the conclusion that the susceptibility per unit volume at absolute zero should be proportional to the number of magnetons per unit mass or inversely proportional to the molecular weight. L. L.

1763. *Change of Electrical Resistance of Graphite in the Magnetic Field.* **G. E. Washburn.** (Ann. d. Physik, 48. 2. pp. 236–250, Oct. 14, 1915.)—An investigation of the change produced by the magnetic field in the electrical resistance of graphite when the current runs parallel to the principal crystallographic axis and the angle between the axis and the lines of magnetic force varies from 0° to 90° [see Abs. 117 (1913)]. A number of specimens were prepared from Ceylon, Mexican, and American graphite and different methods of mounting the current and potential leads were employed. X-ray interference photographs taken in the case of one specimen (2 mm. × 2 mm. × 0·1 mm. thick) enabled the author to determine the ratio of the axes ($c/a = 1{\cdot}633$). A Kelvin bridge was employed to measure the resistance of the specimens. The resistance-change in the magnetic field when the specimen was rotated can be expressed in the form $\delta R/R = a + b\cos\phi$, where ϕ is the angle between the principal axis and the direction of the magnetic field and $a = \delta R/R$ for $\phi = 90°$. The magnitude of $\delta R/R$ is 6 to 7 times greater in the maximum than in the minimum position. The increase of resistance in a field of 30,000 gauss, the axis being parallel to the lines of force, is about 80 %. The author also deduces the specific resistance of graphite parallel to the principal axis and finds it to be 80 to 90 × 10^{-4} ohm-cm. This is about 100 times the value in the direction normal to the axis. This large value cannot be ascribed to indifferent contacts between cleavage planes, since the limits of variation of the specific resistance for the large number of specimens tested are relatively narrow. L. L.

1764. *Current produced in a Metal Plate when subjected to a Magnetic Field.* **V. Volterra.** (Accad. Lincei, Atti, 24. pp. 220–234, Feb. 25, and pp. 289–303, March 12, 1915. N. Cimento, 9. pp. 23–79, Jan.–Feb., 1915.)—A mathematical paper on the Hall-effect. [See also Corbino, Abs. 1134, 1135 (1915).] L. H. W.

1765. *Chronometric Methods for determining the Earth's Magnetic Field.* **J. Andrade.** (Comptes Rendus, 161. pp. 345–348, Sept. 20, 1915.)—If in a non-magnetisable chronometer a magnetised needle be fixed to the balance-wheel in such a way as not to disturb the equilibrium with reference to its axis of rotation, then to forecast the behaviour of such a chronometer constitutes a problem identical with the determination of the perturbation of isochronism due to a change of centre of a chronometer balance-wheel oscillating in a vertical position. The couple applied to the needle, and due to the horizontal component of the terrestrial magnetic field, plays the rôle of the weight in the decentred balance-wheel. The latter problem has been solved by Phillips to the first order of approximation, and the present author now completes the solution by means of the transformation above indicated. By this means the magnetic component can be estimated with a relative error less than the annual variation of the magnetic field. This method, very slightly modified for thermometric corrections, should be very useful to explorers for magnetic determinations. In magnetic observatories an accuracy is claimed to 1 in 100,000. H. H. Ho.

1766. *Initial Magnetisation.* **P. Weiss** and **J. de Freudenreich.** (Archives des Sciences, 39. pp. 125–148, Feb., 1915.)—The susceptibility can be expressed by $k = a + b\mathrm{H}$, where a and b are constants. Radanovic has found the relation for nickel, $b = a^4/1225$, whilst Renger obtained the relation $b = \mathrm{A}a$ for magnetite, and $b = \mathrm{A}a^{5/3}$ for iron. The present paper describes an extension of the study of the coefficients a and b to Fe_2Ni. The ballistic method was employed with rings of trapezoidal section. The susceptibility increased to a maximum at 144° C., the critical temperature being reached at 280°. The k, H curves for temperatures above 144° consist of two straight lines in each case, *i.e.* the phenomenon changes for a value of the field about 0·05 c.g.s. The values of a and b as determined for the initial tests were found to have changed after thermal treatment.

G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1767. *Measurement of Hardness of X-rays by Photographic Methods.* **F. Voltz.** (Phys. Zeits. 16. pp. 306–308, Aug. 15, 1915.)—The best-known practical methods of determining the hardness of X-rays are those of Wehnelt and Benoist. The principle underlying these methods is a comparison of the absorption of varying thicknesses of Al with a definite thickness of silver, a barium platinocyanide screen being used in making the comparison. Accurate comparisons are difficult by these methods, the personal equation of the observer being a serious drawback. It has occurred to the author that photographic methods might be more satisfactory, and the present paper describes an investigation on those lines. As a result of this research it is found that results of "hardness" determinations obtained by the photographic method are not without objections, the experimental values being seriously affected by the material of the photographic plate and other factors. The whole region of medical work in this connection which depends on photographic methods of determining hardness is liable to grave criticism, and in any case is subject to serious corrections. The author considers that this method of determination should in future be entirely discarded. A. B. W.

1768. *Rapid Localisation of Projectiles.* **T. Garraud.** (Archives d'El. Médicale, 28. pp. 319–324, Oct., 1915.)—The direction of the foreign body is given first of all by radioscopic observation if possible, if not by radiography. To determine its depth the usual method of displacement of the bulb is adopted, two impressions being thus obtained on the same negative. The principal feature of the present arrangement is that the depth of the projectile can be obtained by a direct reading. The positions, relative to the same edge of the plate, of the images on the negative and the bulb when those images were taken are obtained by materialising in space the normal ray emitted by the tube. The method of doing this is fully described. A. E. G.

1769. *Marion-Danion Method of Localisation of Foreign Bodies.* **Marion.** (Publ. by L. Maretheux [18 pp.], Paris, 1915.)—This apparatus dispenses with all calculations and diagrams in which it is so easy for mistakes to occur. It requires no previous acquaintance with the particular method, and can be accomplished in a few minutes. It has been in use for several months, and the precision obtainable has been proved of a high order. In using the apparatus there are three main operations: (1) taking the negative; (2) regulation of the "compass" according to this negative; (3) application of the "compass" upon the patient and the extraction of the foreign body. Each of these points is dealt with in detail, and illustrations of the apparatus are given, together with the method of employing it. Accounts of some of the results obtained show the uses to which this method may be put. A. E. G.

1770. *Radiographic Localisation of Projectiles.* **F. Ozil.** (Rev. Élec. 24. pp. 90–93, Aug. 6, 1915.)—The method here described requires no knowledge of the relative positions of the luminous source and of the plate, nor any measurement of the displacement of the bulb. The additional apparatus required is extremely simple, easy to construct and not costly. The principle is as follows: Let A be a mark fixed in space, a its known orthogonal projection upon the plate, and let the height $aA = h$; B is a second fixed mark, b its projection, and h' its height; P is the foreign body, p its unknown projection, and z its unknown height. The plate being placed under the patient, the first negative is taken, the luminous source being at S_1. Let the points A, B, P give the images a_1, b_1, p_1. The luminous source is now moved to S_2, the plate and patient remaining in the same positions. A second plate is now taken, and the points a_2, b_2, p_2 obtained. The six points found, together with a and b, are now indicated on a sheet of paper. Lines joining a_1a, b_1b cut in s_1, while those joining a_2a, b_2b cut in s_2; s_1p_1 and s_2p_2 cut in p. From the data so obtained the values of z, etc., can be calculated. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1771. *Density of Argon.* **H. Schultze.** (Ann. d. Physik, 48. 2. pp. 269–272, Oct. 14, 1915. From the Physikal.-Techn. Reichsanstalt.)—For the specific gravity of spectroscopically pure argon at 0° and 735 mm., the author obtains the values, 0·00178374, 0·00178371, and 0·00178367, the mean value at 0° and 760 mm. being 0·00178376. For the molecular weight, related to that of oxygen as 32, this gives 39·945; Ramsay and Travers [Abs. No. 2415 (1901)] found 39·91 and Watson [Abs. No. 1177 (1910)], 39·88. T. H. P.

1772. *Absorption of Air by Charcoal cooled to the Temperature of Liquid Air.* **C. T. Knipp.** (Science, 42. pp. 429–430, Sept. 24, 1915.)—This absorption may be shown well in two ways. (1) A bulb containing freshly burned coconut charcoal is connected with a discharge tube operated by means of an induction coil and provided with a vent closed by a valve. In parallel with the discharge tube is an alternative spark-gap S. When the charcoal bulb is gently immersed in liquid air, the spark at S weakens and then ceases, while the first stringy discharge in the tube is followed by the characteristic Geissler-tube glow, and by fluorescence of the walls of the tube. This increases until the tube becomes uniformly apple-green and then fades, the reappearance of sparking at S indicating that the vacuum is becoming hard. The reduction from ordinary atmospheric pressure to about 0·001 mm. mercury may be effected in 5 to 6 minutes. (2) A vertical tube dipping in mercury has a widened part 20 cm. in length and 2·8 cm. in diam. At a point at least 78 cm. above the mercury the tube is connected with a charcoal bulb 10 cm. long and 2·5 cm. wide. Cooling of the charcoal bulb in liquid air is accompanied by rise of the mercury, this being at first slow and subsequently rapid, the total time occupied being only 5 to 6 minutes. T. H. P.

1773. *Leakage of Gases through Quartz Tubes.* **E. C. Mayer.** (Phys. Rev. 6. pp. 283–291, Oct., 1915.)—The purpose of this investigation was to determine the leakage of hydrogen, nitrogen, and oxygen through a quartz tube and to see if there existed any relation between the amount of leakage and the pressure and temperature of the gas. A quartz tube of the transparent variety was found to be pervious to hydrogen at temperatures ranging from 330° to 710° C., and at pressures varying from 20 cm. below to 20 cm. above atmospheric pressure. In the case of oxygen and nitrogen, no leakage could be detected for pressures less than 1 atmo. Nitrogen did not appear to escape until a temperature of 430° C. was obtained. At constant temperature, the results for all gases showed considerable increase in leakage with increasing pressures. Under approximately the same conditions, hydrogen leaks most rapidly and nitrogen least rapidly. The author suggests that the results may be explained by assuming that if the quartz contains occluded gas, this gas is in equilibrium and forms a constituent part of the quartz itself. He considers that this occluded gas does not affect the process of diffusion in any other manner. A. B. W.

1774. *Condition of Atoms in Crystals.* **A. Johnsen.** (Phys. Zeits. 16. pp. 269–272, Aug. 1, 1915.)—The author of this paper refers to the work of Laue and the Braggs on the investigation of the arrangement of the atoms in crystals. After discussing the bearing of this work on the question of atom-symmetry he draws up a table in which are indicated the symmetry-groups of a large number of crystals as well as the symmetry groups (Minimal-symmetrien) of their constituent atoms. It is at once evident from a consideration of this table that the atom-symmetry of a particular element is totally different in different crystals. For example, the atom-symmetry of oxygen in $NaNO_3$ is monoclinic, whilst in dolomite $CaMg(CO_3)_2$ it is triclinic. Some interesting characteristics of this so-called atom symmetry are included in a second table, and discussed subsequently. A. B. W.

1775. *Loss of Weight of Musk in a Current of Dry Air.* **C. B. Bazzoni.** (Frank. Inst., J. 180. pp. 468–469, Oct., 1915.)—By means of a flexure micro-balance with which a rotation of 1 head division of the micrometer screw of the reading microscope corresponds with 0·00007 mgm., the author has investigated the loss in weight of musk in a current of dry air. The total weight of the musk taken, which was previously dried in an oil oven at 120°, was 1·82245 mgm. and the loss in weight in about 7 months amounted to 0·18941 mgm. or 14 %. The resultant product is not odorous and does not become so on exposure to moist air.

The drift phenomena due to viscosity or to fatigue and to temperature-changes in the fibre are to be treated in a separate paper. T. H. P.

1776. *Penetration of Glass by Electric Sparks and Rays.* **G. Quincke.** (Ann. d. Physik, 48. 1. pp. 113–144, Sept. 28, 1915.)—The emanations from electric sparks and from metallic wires melted, vaporised and pulverised by the discharge current of a large Leyden battery, penetrate and melt glass and spread through it like water through swelling glue, forming periodically oily liquids, which solidify with varying rapidity to foam-walls of types I and II [Abs. 1148 (1915)]. When these foam-walls and the enclosed chamber contract unequally on cooling and solidification, the walls develop superficial fractures or air-filled cracks showing Newton's rings. Further, the air-particles and gaseous ions carried into the pasty glass form layers of air which exhibit Newton's rings and under the influence of surface tension assume the same forms as thin layers of a pasty liquid in either air or a second oily liquid. These and many other phenomena are described in detail and illustrated by means of photographs. The quantity, quality, and velocity of the electric emanations determine the quantity, surface tension, and shape of the solidifying electrical foam-walls and air-filled cracks formed in the glass.
T. H. P.

1777. *Condensation Nuclei produced by Action of Light on Iodine Vapour.* **H. Pealing.** (Phil. Mag. 29. pp. 413–419, March, 1915.)—A continuation of the author and Owen's earlier work [Abs. 1174 (1911)] in order to test Ramsauer's objections [Abs. 1282 (1912)] to the authors' results. All the experimental results are consonant with the third explanation previously given [*op. cit.*], but the author is unable definitely to state that it is the correct one. L. H. W.

1778. *The Electron Theory in Organic Chemistry.* **N. P. McCleland.** (Phil. Mag. 30. pp. 665–675, Nov., 1915.)

1779. *Construction of Compound Molecules with Theoretical Atoms; the Organic Compounds of Carbon and Hydrogen.* **A. C. Crehore.** (Phil. Mag. 30. pp. 613–628, Oct., 1915.)—The equations obtained in a previous paper [Abs. 1189 (1915)] are here applied in an attempt to explain some of the complex phenomena connected with hydrocarbon compounds. L. H. W.

1780. *A Study of the Quality of Platinum Ware.* **G. K. Burgess** and **P. D. Sale.** (Bureau of Standards, Bull. 12. pp. 289–316, 1915.)—A more complete account [see Abs. 1349 (1915)].

1781. *Can the Dissociation Theory be applied to Solid Solutions in Steels?* **E. D. Campbell.** (Am. Chem. Soc., J. 37. pp. 2039–2046, Sept., 1915.)—A steel of the composition 0·85 % C, 0·08 % Mn, 0·009 % P, 0·024 % S, and 0·18 % Si was cut up into bars 15 cm. in length by 6 mm. square and water-quenched from 892° C. The bars were then annealed at temperatures varying from 20° to 800° C., after which treatment each bar was tested for specific resistance and colour carbon-content. The results indicate that there is a very close relationship existing between the amount of carbide in solid solution and the specific resistance of the steel, both being similar functions of the temperature of annealing. If the iron be regarded as a solvent in which the relations between it and the solutes in true solid solution are essentially the same as those existing in an ordinary solution, then a satisfactory explanation of the correlation of the concentration of the carbides and the specific resistance can be found. In the study of metallography attention is usually focused on the properties of the solvent, whereas in physical chemistry it is customary to study the influence of concentration, temperature, etc., on the solutes. A little consideration shows that the dissociation theory is just as applicable to solid solutions as to liquid solutions, but it must not be forgotten that in the case of aqueous solutions the solvent is to all intents and purposes an insulator, while in the case of metallic solid solutions the solvent is a very good conductor, and it is to this fact that the difference in electrical behaviour of the two types of solutions must be ascribed. *Errata* (Ibid. p. 2522, Nov., 1915). F. C. A. H. L.

1782. *Properties of Cold-worked Metals.* II. *Methods of measuring Small Changes of Density produced by Annealing.* **R. G. Parker** and **T. M. Lowry.** (Chem. Soc., J. 107. pp. 1160–1168, Aug., 1915.)—The small changes of density which are undergone by cold-worked metals when subjected to the process of annealing may be measured either by means of a pyknometer or by means of a dilatometer. With the object of comparing the two methods the authors have studied the effects of annealing on carefully prepared filings of certain metals and alloys. In the pyknometer, ethylene bromide (density 2·18) was generally used as the filling liquid, but in cases where this compound reacted with a particular metal it was replaced by carbon tetrachloride (density 1·6). In the dilatometric method, the fraction of highly purified paraffin boiling between 245° and 280° C. was used as the filling liquid. The precautions to be taken and the corrections to be applied in both methods are discussed in the paper at some length, and it appears from the results that each method has its advantages and limitations. With the pyknometer it is possible to measure the whole of the alteration undergone at a given temperature, while the dilatometer is specially adapted for following the course of annealing at constant temperature. F. C. A. H. L.

1783. *Spontaneous Generation of Heat in Recently Hardened Steel.* **C. F. Brush.** (Am. Phil. Soc., Proc. 54. pp. 154–164, May–July, 1915.)—By means of careful experiments carried out in an apparatus specially designed for the purpose it has been proved conclusively that both carbon and high-speed steels undergo a spontaneous generation of heat for considerable periods of time after hardening. In a sample of carbon steel the total amount of heat generated represented energy sufficient to raise the sample through a height of 800 ft. against the force of gravity. Further experiments showed that during the period of generation of heat (which persisted for over a month) there was an appreciable diminution in the length of the bar. However, the work done in shrinking is nothing like sufficient to account for the total amount of heat generated. The author regards hardened steel as being in a condition of very great molecular strain, which is very unstable, and more particularly so immediately after hardening. Spontaneous relief of a small portion of this strain is accompanied by a rise in the temperature until stability is attained. F. C. A. H. L.

1784. *Electric Furnaces for Heating Steel.* **A. Hirsch.** (Iron and Steel Inst., Carnegie Schol. Mem. 6. pp. 68–98, 1914.)—Gives useful information as to energy required, etc., but not in a form suitable for a short abstract. L. H. W.

1785. *Gases occluded in Liquid Steel.* **L. Barraduc-Muller.** (Iron and Steel Inst., Carnegie Schol. Mem. 6. pp. 216–230, 1914.)—A preliminary account of a research that is not yet concluded. L. H. W.

1786. *Potential of the Rubidium Electrode.* **G. N. Lewis** and **W. L. Argo.** (Am. Chem. Soc., J. 37. pp. 1983–1990, Sept., 1915.)—The method previously used for the determination of the electrode potential of sodium, etc. [Abs. 969 (1912)] has been extended to rubidium. Ethylamine and propylamine are inapplicable as solvents, but mixtures of ethylamine and ammonia exhibit moderately satisfactory behaviour in this respect.

As is shown in the following table, the potentials of the alkali metals follow the order Li, Rb, K, Na, which is also the order of the heats of formation of the ions in aqueous solution.

	Potential against Normal Electrode.	Potential against Hydrogen.	Heat of Formation of Chloride.
Li	3·305	3·027	102,000
Rb	3·205	2·928	101,000
K	3·203	2·925	101,000
Na	2·993	2·715	96,000

Assuming the accuracy of the value, 105,000 gm. cals., given for the heat of formation of aqueous cæsium chloride, the potential of cæsium would be expected to exceed those of all the other alkali metals. T. H. P.

1787. *Electrolysis of Solutions of the Rare Earths.* II. **L. M. Dennis** and **P. A. van der Meulen.** (Am. Chem. Soc., J. 37. pp. 1963–1976, Sept., 1915.)—In continuation of previous work [Abs. 618 (1915)] the decomposition voltages of neutral normal solutions of the nitrates of thorium, neodymium, lanthanum, and cerium, and of the chlorides of thorium and cerium, using Pt electrodes, have been determined. The values obtained lie close together in the neighbourhood of 2 volts. Fractional electrolyis of a solution of the chlorides of the yttrium earths, using a mercury kathode, gave a rapid concentration of the coloured earths in the earlier fractions, and of yttrium in the later fractions. A small amount of neodymium that was present appeared in the last fractions. Similar results were obtained with solutions of the nitrates, using a diaphragm, but the rate of the precipitation of the hydroxides of the rare earths was 4 times as rapid as from the chloride solutions; no ammonium salts were formed during the electrolysis. Fractional electrolysis of a solution high in erbium, holmium, thulium, and yttrium, in a series of 6 fractions, rapidly separated the yttrium from the 3 other earths, but brought about no appreciable separation of the first 3 earths. The results obtained show that by fractional electrolysis rapid concentration of certain groups of earths is attained in a short series of fractions, the hydroxides of the earths being precipitated in the order of their basicities. T. S. P.

1788. *Anodic Potentials of Silver.* II. *Their Rôle in the Electrolytic Estimation of the Halogens.* **J. H. Reedy.** (Am. J. Sci. 40. pp. 400–412, Oct., 1915.)—In the previous paper [Abs. 1594 (1915)] the author has shown that the "solution potential" of silver in the presence of various electrolytes, is 0·521 volt. Below this potential (at the anode) no silver goes into solution. The relation between the "reaction potential" at a silver anode and the concentration of the halogen ions was also determined, and from these results the author deduces that the max. potentials allowable at a silver anode for the deposition of Cl, Br, and I respectively are 0·505, 0·400, and 0·190 volt. It is then shown that bromine and iodine can be estimated satisfactorily by deposition on a rotating silver anode, using the method of graded potential, but that low results are obtained with chlorine, owing to some solution of silver taking place, since the limiting potential of 0·505 volt is very near to the solution potential of Ag. It is further shown that, within certain limits of concentration, a quantitative separation of the halogens is possible. All the experiments were carried out in 0·5 molar solution of sulphuric acid.

The author does not put forward the processes described as analytical methods, the apparatus necessary being too elaborate for ordinary use.

T. S. P.

1789. *Electrostatic Measurement of Electrode Potentials.* **A. W. Ewell.** (Phys. Rev. 6. pp. 271–282, Oct., 1915.)—The electrolyte was contained in an insulated glass flask of 50–150 cm.^{3} capacity. The outside of the flask, except the neck, was coated with a thin metallic film (Ag oval) which could be connected, by an appropriate arrangement, either with a Dolezalek electrometer, or to earth, or to a source of known potential. An electrode could be moved up, or down into the electrolyte. If the electrolyte was initially at zero potential, upon introduction of the earth electrode it would acquire a potential equal to its natural absolute potential with reference to the particular electrode. A charge at somewhat different potential would be induced upon the metal film upon the outside of the flask, and the deflection of the electrometer would be proportional to this potential. The apparatus having been calibrated the potential of the electrolyte could then be ascertained. The calibration was effected by observing the difference in the deflections for zinc and silver and comparing this with the known p.d. between zinc and silver electrodes in normal solutions of their salts.

It was found that the potential of a metal (Zn or Ag) in a normal solution of one of its salts is about 0·5 volt more negative than the potential deduced from electrocapillary phenomena. By an appropriate modification of the apparatus it was also shown that the potential of the metal decreases as the concentration of the solution increases. [See Abs. 1246 (1907).] T. S. P.